Line correction and tie levelling (T30)

Top

Measurements taken during traverses are subject to errors or undesirable data from a number of sources. These include:

- Interaction between the direction of the Earth's magnetic field and that of the aircraft may be affecting the measurements.
- The aircraft position is measured using an instrument inside the aircraft, but some data (e.g., magnetic) may be taken from a sensor at the end of a cable some distance from it. The measurements may therefore be incorrectly located. This is called **systematic parallax** error.

  Variable aircraft speed may create an additional **variable parallax** error due to the navigation instrument and acquisition instruments having a variable time difference in passing over points in the survey area.
- There may be inaccuracies in recording the survey craft's location and/or height when a measurement is taken.
- There will be a certain error in recording the aircraft attitude, and even if the instruments are on a stabilized platform, Roll,Pitch and Yaw estimated values will have an error, and for gradiomtery, this error will leak into the signed tensor components.
- The readings are all taken at different times. If the background magnetism or radiation is changing during this time, these changes will confound the measurements.
- Magnetic measurements will include the Earth's core magnetic field.
- The zero settings of older magnetometers vary exponentially with time (this is called **magnetometer drift**).
- Measurements will be affected by the ground clearance of the survey craft.

  Luyendyk (1997)[1] gives a comprehensive description of the sources of error in aeromagnetic surveys and the corrections that can be applied.

  The Levelling tool will assist you to correct these errors. It measures and represents graphically the discrepancies between your acquisition lines and tie lines. It then corrects your data using the geomagnetic reference data and by comparing it with tie line and base station data.

Levelling Pro

The Pro version of the Tie Line Levelling tool uses sophisticated tensor and gradient methods for altitude and heading correction and for loop levelling. It uses the same task description (job) language as the standard version. At v5.0, this is depricated by a new GOOGLE protobuf syntax that describes all this tool's processes in a unique, and fully transparent language, which INTREPID is publishing, along with new example instances of the task control language, duplicating all the previously published examples. The V5.0 strategy is to support both old and new syntax, to allow you to transition, and verify that all works as required.

This means that the algorithmic compatibility for all existing scalar geophysics measurements is also extended to include support for new tensor/vector measures, for all the supported levelling methods. You can easily assess it relative to the existing

1. Luyendyk, A. P. J., (1997) Processing of airborne magnetic data, *AGSO Journal of Australian Geology and Geophysics*, 17 (2), 31–38

© 2012 Intrepid Geophysics

production tool.

We retained the GUI of the old tool but made engine room improvements one by one. We completely rewrote and restructured the engine room to use INTREPID's powerful data objects.

Tie Levelling Pro can process any of the new vector, tensor, quaternion style data fields in a database. However, probably the best way to check on available functional status of any of the levelling methods, is to directly examine the "**intrepid-tasks.proto**" file at V5.0, to confirm what you would like to do is supported. The complete re-write and generalization of the engine room is not a simple or linear process. It has already taken a lot of time and effort to get things to fall into place.

Our new levelling support library integrates the previous independent codes for airborne and the special methods we developed to serve the marine levelling tools.

Marine levelling cross-overs include an estimate of the strike and dip of the measured field at the cross-over point. This is useful for 3D GeoModeller when we have seismic picks for different horizons.

We generalise all statistics for fields in the same way. We have rewritten all operations such as interpolation and filtering support the new data types.

Tie Line Levelling Pro includes a new section especially for tensor data. This is particularly useful for gravity tensors. You can add or remove Earth effects.

We have generalised the Heading correction to take advantage of the fact that for most surveys there are 4 cardinal directions employed during surveying. the survey team gathers group statistics for these 4 directions and we use such data as the various systematic tensor and vector differences as the basis for the Heading correction. This avoids the difficult task for the user of having to estimate these heading errors before being able to apply the correction.

There is also a new Altitude correction. This uses a locally fitted truncated Fourier series to the potential. With this series, on an observation by observation basis, we make the altitude adjustment to a drape surface.

The Loop levelling algorithm is a least squares minimum residual method. We also rewrote this to so that it works on Tensor data. The Frobenius norm of the cross-over difference has proven a driving measure to minimize residuals.

As well as Tensor, the other common case for airborne geophysics is the observed scalar field together with measured gradients. Tie Line Levelling Pro uses a single pass method to level the complete signal.

Tie Line Levelling Pro can perform this using both the heading and loop levelling methods.

We are still developing the generalised Polynomial levelling method. So far it continues to work for scalars., and there is primary testing to show it working on tensors as well.

Using the Levelling tool

You can set up the Levelling process in the following ways:

- Use the Levelling tool wizard.
- Use the menu options and controls in the Levelling tool window

© 2012 Intrepid Geophysics

>> *To use the Levelling wizard*

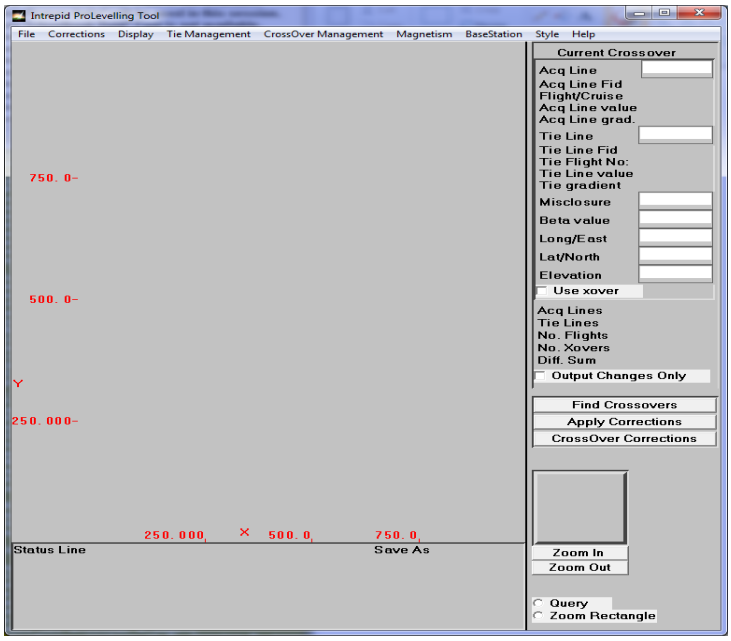
1 From the File menu, select Wizard for Easy Levelling.

2 Follow the wizard steps, referring to corresponding sections in this chapter as required.

© 2012 Intrepid Geophysics

>> *To use the Levelling tool*[1]

1. If required, ensure that correctly configured aliases exist for the dataset you are levelling. In particular, if you are reconstructing the flights using a time field which has the time for each data point, assign the time field to the **Fiducial** alias. See Specifying input and output files for details.
2. Choose Tie_Line_Levelling from the Levelling menu in the Project Manager or use the command **`newlevel.exe`**. INTREPID displays the Levelling window.



3. Specify the Signal field of the line dataset whose values you wish to level. Use Specify Input from the File menu. See Specifying input and output files for detailed instructions.
4. Specify field names for your corrected data (or corrections) using Specify Output from the File menu. INTREPID displays Save dialog boxes for X Y and Signal in turn. See Specifying input and output files for detailed instructions.
5. If required, sort the data into chronological order (INTREPID sorts its working copy of the data– not the dataset itself). Choose Reconstruct Flights from the File menu, and select either Date/time, Julian Day or Fiducials as a basis for the sorting. See Chronological order—reconstructing the flights for detailed instructions.
6. If required, obtain the Crossover data—the data points where there is both an acquisition line and a tie line reading for the same location. To calculate the crossovers use Find Crossovers at the bottom right of the Levelling window. To load an existing crossovers dataset, use Load Crossovers from the file menu. INTREPID displays the crossover data graphically. See Calculating crossovers and Creating and Using Crossovers Datasets for detailed instructions.
7. Disable crossovers you wish exclude from the levelling process, if any. See Excluding crossovers from the levelling calculation for instructions.

---

1. This summary assumes that you are performing an entire typical levelling process in one session. You can save intermediate data and continue work in a different session or repeat stages of the process as required. You can vary many of the steps described here. See the following sections of the manual for more detail.

© 2012 Intrepid Geophysics

8 Specify the corrections you require. Use the options in the Corrections menu, entering any parameters required in the dialog boxes that INTREPID displays. See INTREPID Levelling corrections and the sections following it for detailed instructions.

Some corrections require preliminary operations before you select their option from the Corrections menu:

- If you are performing Diurnal corrections you must load the base station dataset before specifying the correction. See Diurnal corrections for instructions.
- If you are using Polynomial levelling, you will need to select the principal tie line and specify the levelling order for the other tie lines. (See Polynomial levelling for instructions.)

9 **Viewing the data**. You can:

- Choose between Markers and Colours for your data display using the options in the Style menu. (See Display style—markers vs colours for detailed instructions.)
- Use the Zoom In, Zoom Out buttons and the Pan/zoom location indicator to adjust the magnification and position of the display. (See Panning and Zooming the display for detailed instructions.)
- View crossover data graphically in the dataset display area. Use the options in the Display menu to choose the display you require. See Crossover and line display options for detailed instructions.
- View a profile graph along a single tie line. See Displaying profiles along individual tie lines for detailed instructions.
- View a profile graph of base station data for a flight or day. See Flight/Cruise or Day profile graphs for details.
- View values for individual crossovers. See Examining individual crossovers for instructions.

10 Saving crossovers: You can save the current crossovers and proposed corrections at any stage after obtaining the crossover data for the session. See Proposed corrections and crossovers datasets and Creating and Using Crossovers Datasets for instructions.

11 When you are satisfied that the corrections are as you require and if you wish to carry out the corrections, choose Apply Corrections near the bottom right corner of the Levelling window. INTREPID will apply the corrections to the whole set of data. See Applying the corrections to the whole dataset for instructions and options.

12 If you wish to record the specifications for this process in a **`.job`** file in order to perform a similar Levelling task in batch mode, use Save Options from the File menu. (See Specifying input and output files for detailed instructions.)

13 If you have corrections to make to another dataset, repeat steps 3–12 for the another dataset.

14 Exit from Levelling by choosing Quit from the File menu.

—

© 2012 Intrepid Geophysics

You can view Help information by choosing options from the Help menu (See Help).

You can execute Levelling in batch mode using a task specification (**.job**) file that you have previously prepared. See Displaying options and using task specification files for details.

Preliminary processes

The following table lists the corrections available in this tool and the preliminary processes required before you can perform them.

	Reconstruct flights	Specify base station data	Calculate crossovers	Specify tie line list
Parallax				
Heading				
Diurnal	yes	yes		
GRF	yes			
Level XY	yes		yes	
Polynomial	yes		yes	yes
Loop closure	yes		yes	

Suggested Levelling regimes

The Levelling tool can perform a number of levelling functions in the same session. It will be appropriate in some circumstances for you to complete your levelling operations over several Levelling sessions.

We recommend that after performing a correction on a dataset you exit from Levelling and launch it again for the next task.

The following regimes are a pair of extremes. Generally speaking, apart from the Parallax correction, which you should always perform first, you can combine corrections or perform them separately as required.

New datasets

If you are processing fresh data, you will most likely wish to grid the results of each step and examine them before proceeding to the next. We recommend the following Levelling sessions for an unfamiliar dataset. Repeat each step until the results are the best possible. Note the parameters that you used to produce this result.

1. Perform Diurnal and GRF corrections, then grid and examine the results. These corrections may be performed together.
2. Perform Parallax corrections, then grid and examine the results.
3. Perform Heading or Level XY or Polynomial or Loop Closure corrections as required, then grid and examine the results.

© 2012 Intrepid Geophysics

Datasets for which you have established required correction parameters

If you are reprocessing a dataset and know the correction parameters you require, you can perform most of them in the same session. You must perform the Parallax correction separately. We recommend the following levelling sessions.

1 Perform Parallax corrections.

2 Perform all other corrections.

Components of the Levelling window

The menu bar has pulldown menus that enable you to operate the Levelling application

The dataset display area occupies most of the window. This area shows the data you are processing and has Latitude and Longitude as its axes.

The individual crossover display area enables you to

- View values for individual crossovers,
- Disable and enable individual crossovers,

The Pan/zoom indicator and Zoom buttons enable you enlarge and reduce (zoom) the display and select different parts of it for viewing (pan)

The status line at the bottom left of the Levelling window shows information about the current files and activity.

The calculations command buttons enable you to find the crossovers and apply the corrections to the data.

Specifying input and output files

To perform Levelling you will need to specify the Signal field of the line dataset to be levelled, as well as the location fields, the fiducial field and the flight number field. If you are reconstructing the flights using flight dates and times, you must also specify a flight date field and, optionally, a time field.

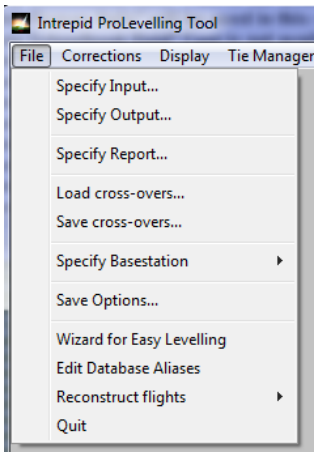
The levelling process will produce corrected data (or corrections) in the form of a corrected Signal field and/or corrected X and Y fields. You will need to specify names for these fields.

You may also need to specify a base station dataset for diurnal data.

You can save the crossover point data for examining using other INTREPID tools, then load it for use during a subsequent levelling session.

Most file operations are listed in the File menu.

© 2012 Intrepid Geophysics



© 2012 Intrepid Geophysics

In each case INTREPID displays an Open or Save As dialog box. Use the directory and file selector to locate the file you require. (See "Specifying input and output files" in Introduction to INTREPID (R02) for information about specifying files).

INTREPID can obtain information from the dataset aliases. It can use the following aliases to identify appropriate field files:

Alias	Field
X	X coordinate (location)
Y	Y coordinate (location)
Line Type	Line type
Line Number	Line number
Fiducial	Fiducial count
Flightnumber	Flight number
Clearance	Sensor height[a]

a. This alias normally refers to the distance from the sensor to the ground. In Levelling, the field is only used for the GRF correction, and may therefore be any sensor height measure. See The geomagnetic reference field in INTREPID (R15) for details.

If your survey has a time field containing the time for each data point and you wish to reconstructing flights using this field, you must assign the time field to the **Fiducial** alias. See Chronological order—reconstructing the flights for details of this process.

If there is no flight number field in the dataset you can still perform all levelling corrections except for 'Levelling the flights assuming that the tie lines are correct' in Polynomial levelling. You should omit this process if you are performing the Polynomial levelling correction. See The Polynomial 'drift estimation' levelling method and Selecting polynomial levelling process stages for instructions.

See "Vector dataset field aliases" in INTREPID database, file and data structures (R05) for more information about aliases.

File menu options

Specify Input Choose Specify Input from the File menu.

INTREPID displays the Load Signal dialog box. Locate the correct dataset directory if necessary. Specify the name of the Signal values field to be levelled and choose Open.

If you have not assigned aliases, or if some aliases are missing, INTREPID will also prompt you to specify the fields missing (See the list above)[1].

1. If your Fiducial field is missing you can create a 'fake' fiducial field for the data using the Spreadsheet tool. Create a new field called **FID** and generate a unique fiducial number for each point in the dataset. See "Frequently asked questions" in Spreadsheet Editor (T15)..

© 2012 Intrepid Geophysics

Specify Output Because some of the corrections involve changes to the location data, you will need to save new sets of X and Y values as well as Signal values.

You can save output corrected values to the output X, Y and Signal fields, or output the corrections themselves. To output corrections, turn on Output Changes Only in the Levelling window. To output corrected values, ensure that the check box is turned off.

Choose Specify Output from the File menu. INTREPID displays Save dialog boxes for X, Y and Signal in turn. For each, specify the name of the new file (or the old one if you wish to overwrite it).

Load Crossovers If you have previously saved a crossovers dataset for the current levelling task, use this to load the crossovers dataset into the Levelling tool. See Creating and Using Crossovers Datasets for details.

Save Crossovers After you have calculated the crossover data, use this to save a crossovers dataset. See Creating and Using Crossovers Datasets for details.

Specify Basestation If you are performing diurnal corrections, use this to specify the base station dataset. See Diurnal corrections for instructions.

Save Options If you wish to save the current Levelling file specifications and parameter settings as an task specification file, use this option to specify the filename and save the file. You can only use Levelling task specification files in batch mode. See Displaying options and using task specification files for more information.

Note: The current version of INTREPID cannot load task specification files for interactive use. You can load previously specified operations to some extent using crossovers datasets, but these operate differently from task specification files. See Creating and Using Crossovers Datasets for information about crossovers datasets.

Reconstruct Flights When you reconstruct the flights using a flight date and possibly a flight time field, you need to specify the fields containing the flight dates and (optionally) the flight times. See Chronological order—reconstructing the flights for instructions.

Editing aliases

You can edit the aliases for any dataset. This process is independent of any currently loaded dataset, so you can use it before or after specifying the Signal field to be levelled

>> To edit the aliases for a dataset

Choose Edit Dataset Aliases from the File menu. See "Vector dataset field aliases" in INTREPID database, file and data structures (R05) for further instructions.

File operations not listed in the File menu

- When you reconstruct the flights, INTREPID automatically saves a flight reconstruction report. See The flight report file for details.
- When you calculate the crossovers, INTREPID automatically saves a crossovers report. See The crossover report file for details.
- You can save and load tie line lists which define the principal and subsequent tie lines for polynomial levelling. See Choosing the principal tie line and the tie line order for details.

© 2012 Intrepid Geophysics

Data display with the Levelling tool

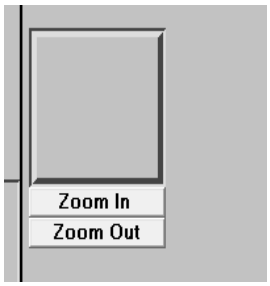
The Levelling tool provides a wide variety of options for displaying your data so that you can examine it.

- You can view numerical information about individual crossover points in the Individual crossover Display Area. See Examining individual crossovers for details.
- You can view a variety of crossover point information graphically in the Dataset Display Area. See Display style—markers vs colours and Crossover and line display options for details.
- You can enlarge, reduce and view different parts of the data in the Dataset Display Area. See Panning and Zooming the display.
- You can view profile graphs in separate windows of
- Diurnal data for a flight or a day. See Flight/Cruise or Day profile graphs for details.
- Tie line data. See Displaying profiles along individual tie lines for details.
- During the polynomial levelling process INTREPID displays profile graphs of the polynomial curves with the errors to be adjusted marked as points in the profile. See Polynomial levelling for details.
- You can save a crossovers dataset and view it in an INTREPID visualisation tool or the Spreadsheet tool. See Creating and Using Crossovers Datasets for details.

Panning and Zooming the display

You can enlarge and reduce the display (zoom in and out) and view different parts of it (pan).

>> To zoom in and out (enlarge/reduce)



To zoom in (enlarge the display) choose Zoom In at the right edge of the Levelling window. Each time you choose this button, INTREPID will enlarge the display by one step.

To zoom out (reduce the display) choose Zoom Out at the right edge of the Levelling window. Each time you choose this button, INTREPID will reduce the display by one step.

© 2012 Intrepid Geophysics

>> To pan the display (view different parts)

The Pan/zoom indicator near the bottom right corner of the Levelling window consists of a small square within a larger square. The large square represents the whole display and the small square the part visible on the screen. When you drag the small square to a different part of the large square INTREPID shows the corresponding part of the display.

If you have zoomed out to view the whole display, the small square may occupy the whole of the large square and may therefore not be visible.

Chronological order—reconstructing the flights

You must reconstruct the flights if you wish to perform any of the following operations,

- Make diurnal or GRF corrections for changes in the background signal (See Diurnal corrections and GRF—Subtracting the Earth's core magnetic field),
- Make crossover-based corrections (See Level XY corrections—inferring the correct location, Polynomial levelling and Loop closure levelling),
- View graphs of data along individual flights (See Displaying profiles along individual tie lines).

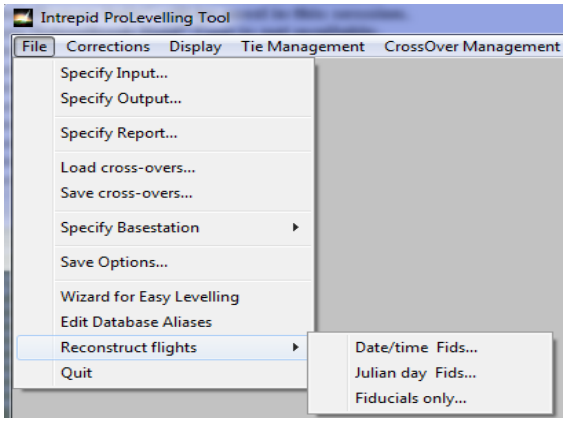
Reconstructing the flights will internally sort the data into chronological order.

If INTREPID only has available the flight numbers and fiducials, it will simply sort the data in order of flights, then the traverse lines of each flight in order of first fiducial value.

If you supply a flight date field and (optionally) a time field, INTREPID will be able to sort the data using these fields.

You must supply flight date and time if you wish to apply GRF and / or diurnal corrections with maximum accuracy (See GRF—Subtracting the Earth's core magnetic field) and

Flight reconstruction involves choosing one of the options from the Reconstruct Flights cascade in the File menu.



The procedures for flight reconstruction differ slightly depending on the option you choose, as described in the following sections.

© 2012 Intrepid Geophysics

Flight reconstruction using flight date and time

If your survey data includes the date of each flight, you can reconstruct the flight on a time basis.

If your survey has a **TimeOfDay** alias field with the time of each reading, INTREPID can use this for reconstructing the flights.

If the survey has a **TimeOfDay** alias field which gives only the starting time of each flight, INTREPID can use it in conjunction with the **Fiducial** alias field to determine the time for each reading.

If the survey has no **TimeOfDay** alias field, INTREPID will calculate the time of each reading from the **Fiducial** alias field. It assumes that fiducial 0 is midnight at the start of the flight date.

Date record and formats

The date must be recorded in integer (4 byte) field of the survey dataset. INTREPID will only examine the first date for each line, so we recommend that the date field be a 'group by' field.

The date can be expressed as

Julian date A positive integer representing the number of days since the beginning of a 'datum year' (A day you regard as a start date for your surveys). In practice, as long as your data is internally consistent, the value of the start date does not matter. If you are using other software with your data, for example, importing it into a general purpose spreadsheet such as Microsoft *Excel*, you may wish to use a start date consistent with the general purpose software you intend to use. (In Microsoft *Excel* a date whose integer part is 1 represents 1 January 1900.)

yymmdd format A positive integer which will represent a date in *yymmdd* format when it is expressed in base 10 using 6 digits. For example, the number 970223 represents the date 23 February 1997.

ddmmyy format A positive integer which will represent a date in *ddmmyy* format when it is expressed in base 10 using 6 digits. For example, the number 050293 represents the date 5 February 1993.

Time record and format

If your dataset includes a time field containing a time for each reading, you can use the time field for reconstructing the flights. In this case you must assign the time field to the **Fiducial** alias before commencing the Levelling session. See Specifying input and output files for details.

If your dataset includes a time field that specifies the start time for each flight (or each line), you can use it and the **Fiducial** field to calculate the time for each reading In this case it would be appropriate for the time field to be a 'group by' field. We can call it a **start time** field.

If your dataset has no time field, then INTREPID assumes that fiducial 0 is midnight sat the start of the flight date.

The time must be expressed in number of seconds since midnight at the beginning of the flight date. For example, 6:30 am will be 23400 (= 60 x 60 x 62).

© 2012 Intrepid Geophysics

Using Fiducial numbers to calculate time

INTREPID will calculate and record internally a time for each data point. For each data point it converts the fiducial count into seconds using the Fiducial factor then adds the value of the start time field if specified, to give the time for the data point since midnight at the start of the flight date.

Fiducial factor This parameter is the sampling interval of the dataset being levelled. For example, a fiducial factor of 0.1 indicates 10 fiducial counts per second. If you have specified a time field expressed in seconds by assigning it to the **Fiducial** alias, you should set the Fiducial factor to 1.

Reconstructing the flights

>> To reconstruct the flights

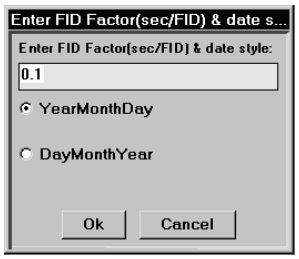
1. Ensure that you have assigned the time field to the **Fiducial** alias if required, commenced the Levelling session and specified the input Signal field to be levelled.
2. Choose Date / Time / Fiducial or Julian Day / Time / Fiducial from the Reconstruct Flights cascade in the File menu.

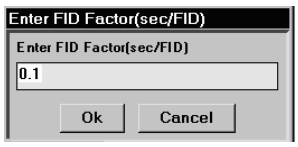
   INTREPID will prompt you to specify the date or the Julian day field, depending on the option you chose from the Reconstruct Flights cascade.
3. Specify the flight date field.
4. INTREPID will prompt you for the flight start time field.

   If you assigned the time field to the Fiducial alias, do not specify the same field as the start time field here.

   If a flight start time field exists, specify it here, other wise choose Cancel.
5. If you specified Date / Time / Fiducial, INTREPID displays the Fid Factor and Date Format dialog box.

   If you specified Julian Day / Time / Fiducial, INTREPID displays the Fid Factor dialog box.





   Enter the fiducial factor. (This would normally be 1 if you assigned the time field to the **Fiducial** alias).
6. Specify the date format if required.
7. Choose OK. INTREPID will reconstruct the flights.

© 2012 Intrepid Geophysics

Flight reconstruction where flight date and time are not available

If you do not have dates and times available for the dataset being levelled, you can reconstruct the flights using flight number and fiducial numbers only. In this case, INTREPID simply sorts the data into order of flight number, then fiducial order within each flight.

>> To chronologically sort the data (using fiducials only)

Choose Flight / Fiducial from Reconstruct flights cascade in the File menu.

If there is no field specified for the **Flightnumber** alias, INTREPID will prompt you for the Flight number field.

If there is no flight number data in the dataset, you can use the line number instead. Without flight numbers you can still perform all levelling corrections except for 'Levelling the flights assuming that the tie lines are correct' in Polynomial levelling. You should omit this process if you are performing the Polynomial levelling correction. See The Polynomial 'drift estimation' levelling method and Selecting polynomial levelling process stages for instructions.

INTREPID will reconstruct the flights.

Internal calculated date and time

INTREPID calculates a date for each line and a time for each data point. It expresses these values in Julian format, with date as a whole number and time as a number between 0 and 1 (a fraction of the day. You can see this data in the flight report file (See The flight report file.

The flight report file

INTREPID produces a flight report file **`flight.rpt`** in the dataset directory. You can examine this file in detail to confirm that the flight reconstruction was correct.

The flight report is an ASCII file which you can print or read/edit with any text editor. It consists of a set of tables—one for each flight. Tables have one column for each traverse line and six rows of data—Line Number, Line Type, original position of the line in the dataset ('Rows'), starting Fiducial number, Julian day, Relative Julian time since the start of the flight.

Relative Julian time is a number representing the time since the start of the flight. Its fractional part represents a fraction of 24 hours. For example, if the flight commenced a midnight, 0.3 represents 7:12 am (0.3 x 24 = 7.2 = 7 h 12 min).

© 2012 Intrepid Geophysics

Here is part of a sample flight report file:

```
FLIGHTREPORT     for   raw_mag

New Flight 1
Lines 2862  2771  2851  2842  2742  2811  ...
Type  Line  Line  Line  Line  Line  Line  ...
Rows  13    4     12    11    1     8     ...
Start Fids 2556802735942843983048523672523758O2...
End Fids257464275376286200306458368900377556...
Julians2448166   2448166    2448166    2448166    2448166    2448166    ...
Relative Julians0.29590.31670.32920.35280.42510.435...

New Flight 2
Lines 2942  2992  2931  2921  7111  2982  3032  ...
Type  Line  Line  Line  Line  Tie   Line  Line  ...
Rows  21    27    20    19    33    26    32    ...
Start Fids 309612329380336802352908497346507152507376...
End Fids311732335183351821365604499188509146508820...
Julians2448166   2448166    2448166    2448166    2448166    2448166
2448166...
Relative Julians0.35830.38120.38980.40850.57560.5870.5872...

Total Numberof   Flights:   2
```

If you do not specify a date field, INTREPID omits the Julian date/time rows of the table.

Calculating crossovers

INTREPID can extract a sample from your dataset containing all of the data points where acquisition and tie lines cross (crossovers). You can use this sample to prepare and test corrections before applying them to the whole dataset. (If there are no crossovers, several of the levelling methods cannot be used) The sample is called the **crossovers**.

The advantages of using the crossovers in this way are as follows:

- The set of crossovers is the focus for several of the Levelling tool corrections.
- Line datasets can be large and slow to process. If you are testing possible corrections, it will save time to use a sample of the data for testing.
- You can save the crossover values as a small sample dataset for easy examination using other tools.

How INTREPID calculates the crossovers

Crossover points and values

INTREPID calculates the crossover values in the following way:

When viewed from above the points at which tie lines and acquisition lines intersect are called **crossover points**.

INTREPID infers the **crossover values** in the tie line and the acquisition line at this point by finding an average of the points on either side of the crossover point. INTREPID weights the contributions of the points to the average according to the distance of the points from the crossover point. The **misclosure** at a crossover point is the original difference between the acquisition line crossover value and the tie line

© 2012 Intrepid Geophysics

crossover value. The **BETA** at a crossover point is the current difference between the acquisition line value and the tie line value. These concepts also apply to tensor/ vector readings.

Crossover gradients

INTREPID calculates the **crossover gradient** with respect to fiducial data in a line at the crossover points. It uses the **Signal** data values on either side of the crossover points to calculate Δ**Signal**.

INTREPID calculates the crossover gradients with respect to the fiducials for convenience. Since the aircraft is likely to be travelling at a constant speed, these gradients are also an accurate estimate of the gradients with respect to distance, and INTREPID uses them as such.

If the gradient at the crossover is high, you may need to pay special attention to it during some corrections. To ensure that it locates a high gradient if it exists at a crossover, INTREPID can search for the highest gradient in the region of the crossover and record that as the gradient at the crossover. See step 3 in Section Calculating the crossovers for instructions.

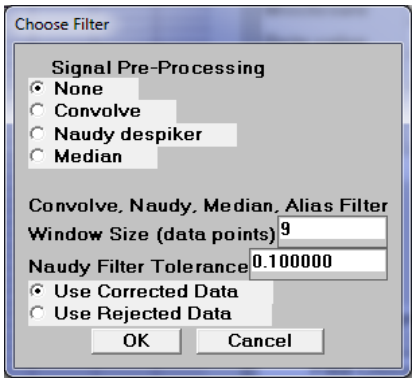
Crossover report

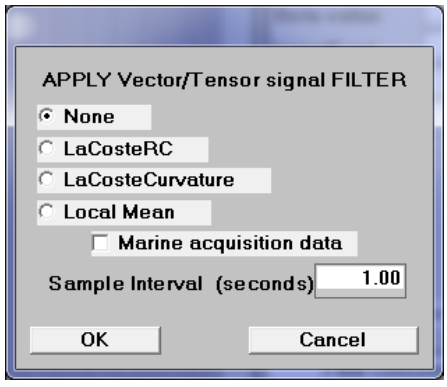
INTREPID writes a crossover report to a file in the dataset directory (See The crossover report file for more details).

Calculating the crossovers

>> To calculate the crossovers

1 Choose Find Crossovers at the bottom right of the Levelling window. INTREPID will specify the Signal Field Pre-Process dialog box. This adapts for scalar/tensor signals.





2 Select the process you require from the Signal Field Pre-Process options. The default process is None.

If you have selected Convolve (Fuller), specify the size of the convolution window in data points, using the Window Size (data points) text box. See "Fuller filter" in INTREPID spatial and time domain filters and transformations (R13) for further information.

If you have chosen the Naudy filter, specify

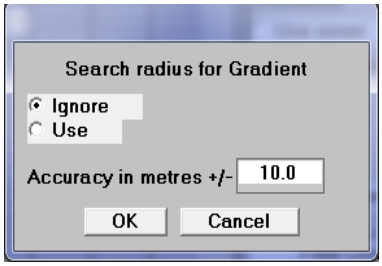
- The filter wavelength (in data points) using the Window Size (data points) text box,.
- The filter tolerance (in Signal units) using the Tolerance text box,

© 2012 Intrepid Geophysics

See "Naudy filter" in INTREPID spatial and time domain filters and transformations (R13)for further information.

© 2012 Intrepid Geophysics

3 Choose OK. INTREPID displays the Search Radius for Gradient dialog box.



4 If you require INTREPID to search the neighbourhood of each crossover point for the highest gradient to record as the crossover gradient, select Use and specify the radius (in metres) around the crossover point for selection of the maximum gradient.

If you wish INTREPID to always record the gradient precisely at the crossover point as the crossover gradient, select Ignore.

See Crossover gradients for further explanation.

5 Choose OK. INTREPID will calculate and display the crossovers, and write the crossover report file.

You can save the crossovers if you wish to use them in a later session without recalculating them. See Creating and Using Crossovers Datasets for instructions.

The crossover report file

INTREPID writes a crossover report to the **`.rpt`** file **`crossover.rpt`** in the dataset directory. This is an ASCII file which you can print or read/edit with any text editor. It consists of a matrix with one acquisition line per row and one tie line per column. Each cell in the matrix therefore represents a potential intersection point. INTREPID represents the potential intersection points as follows:

Type of intersection	Notation
Crossover data calculated	**OK**
Crossover not found but minimum bounding rectangles of acquisition and tie lines overlap (e.g., one line may stop short of the other but its end still lie close to the other line).	tie line number followed by **R**
Crossover not found and minimum bounding rectangles of acquisition and tie lines do not overlap.	tie line number

© 2012 Intrepid Geophysics

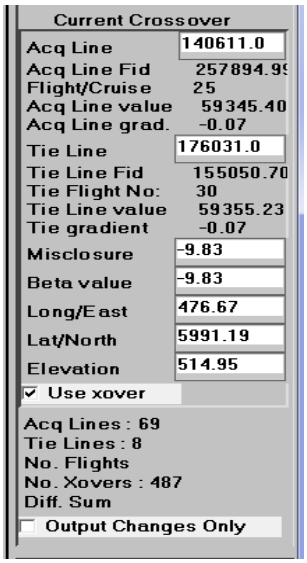
Here is an example of a crossover report file.

```
CROSSOVER REPORT for raw_mag
CROSSOVER GRID CONTAINS  33 LINES AND  3 TIES
CROSSOVER REPORT - CROSSOVERS NOT FOUND INDICATED BY TIE NUMBER,
OTHERS BY OK

      LINE    STATUS OF TIES

      2731    OK   OK  7122
      2742    OK   OK  7122
      2751    OK   OK  7122
      2761    OK   OK 7122R
      2771    OK 7121    OK
      2781    OK 7121    OK
      ...
      3001    OK 7121    OK
      3012  7111 7121    OK
      3013    OK 7121    OK
      3021    OK 7121    OK
      3032  7111 7121    OK

Total number of Crossovers : 63
```

Crossovers datasets

You can save the crossovers for examination or further testing in a later levelling session. See Creating and Using Crossovers Datasets for full instructions.

Examining individual crossovers



At the right of the Levelling window is the **individual crossover display area**. You can use the display areas and text boxes to

- View values for individual crossovers,
- Enable or disable individual crossovers

>> To view data for an individual crossover

Select the crossover you wish to view by clicking it in the dataset display area.

© 2012 Intrepid Geophysics

Data displayed for each crossover

INTREPID displays the following information about the current crossover:

For the current acquisition line:

- Acquisition Line number
- Acquisition Line Flight/cruise number
- Acquisition Line Crossover fiducial
- Acquisition Line Crossover value
- Acquisition Line Crossover gradient

For the current tie line:

- Tie Line number
- Tie Line Flight/cruise number
- Tie Line Crossover fiducial
- Tie Line Crossover value
- Tie Line Crossover gradient

For the current crossover:

- Misclosure
- Beta misclosure (See Proposed corrections and the beta misclosure for a definition)
- Longitude (East)
- Latitude (North)
- Use crossover check box
  - (On if crossover enabled for levelling)
  - (Off if crossover disabled for levelling)

For the whole dataset:

- Number of acquisition lines
- Number of tie lines
- Number of flights
- Number of crossovers
- Cumulative length of all traverses

Output Changes Only:

This check box controls whether the output X, Y and Signal fields contain corrected values or the values of the corrections. It is not part of the individual crossover display. See Applying the corrections to the whole dataset for further details.

© 2012 Intrepid Geophysics

Excluding crossovers from the levelling calculation

For crossover-based corrections (Level XY, Polynomial and Loop Closure) you may wish to exclude some crossovers from the process. You can do this using a condition (logical expression) or by turning crossovers on and off individually.

Crossovers that are turned on (to be included in the corrections) are **enabled**.

Crossovers that are turned off (not to be included in the corrections) are **disabled**.

The Use Xover check box indicates whether the current crossover is enabled for the levelling process. If it is on, the crossover is enabled. If it is off the crossover is disabled. INTREPID still displays excluded crossovers in the dataset display area.

Disabling and enabling individual crossovers

>> To disable a crossover

1. Select the crossover you wish to view by clicking it in the dataset display area with the left mouse button.
2. Turn off the Use Xover check box.

>> To enable a crossover

1. Select the crossover you wish to view by clicking it in the dataset display area with the left mouse button.
2. Turn on the Use Xover check box.

Disabling crossovers using a condition

You can disable crossovers using a condition in the form of a logical expression. The expression must use standard INTREPID expressions notation and can involve any crossovers dataset field name. See Creating and Using Crossovers Datasets for further details about crossovers datasets.

You must save a crossovers dataset in order to use the condition expression.

In the Disable Crossover Points dialog box (see below) INTREPID lists the names of the crossovers dataset fields.

Notes

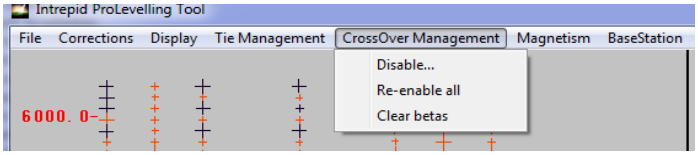
- The crossovers for which the expression is **true** will be **disabled**.
- If you use the crossover gradient in the expression, use the field **`LGRAD`** (e.g., **`ABS(LGRAD)>10`**). There are records for each line in the dataset, so, in fact, each crossover is represented twice in the crossovers dataset—once from the viewpoint of the acquisition line and once from the viewpoint of the tie line. The condition will therefore be applied twice for each crossover. If you specifically wish to apply the condition to acquisition lines or tie lines only, include a reference to line type in the expression (e.g., **`... && LTYPE == 2`** will exclude all lines except acquisition lines).

See INTREPID expressions and functions (R12) for full information about expressions.

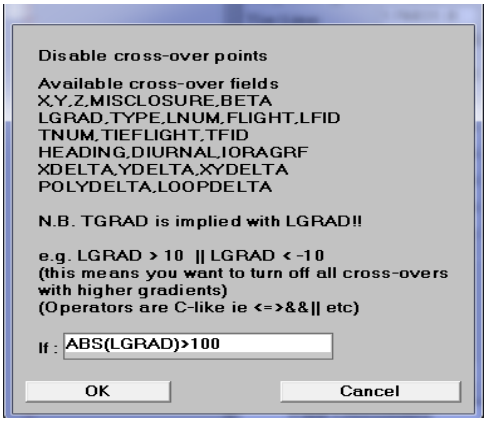
© 2012 Intrepid Geophysics

>> To disable crossovers using a condition

1 Choose Disable from the Crossover menu.



INTREPID displays the Disable Crossover Points dialog box containing a list of the crossovers datasets fields and a text box for the logical expression.



2 Enter the logical expression into the text box, then choose OK. INTREPID will disable the crossovers for which the condition is true.

Enabling all crossovers

>> To enable all crossovers

Choose Re-enable All from the Crossover menu. INTREPID will enable all crossovers.

INTREPID Levelling corrections

There are two types of Levelling correction: crossover-based and immediate. INTREPID records proposed corrections for both types, but only uses them with crossover-based corrections. INTREPID keeps a 'running total' of the corrections you specify as 'beta misclosures'. The following sections contains an explanation of these terms.

Proposed corrections and the beta misclosure

A correction calculated for a crossover is a **proposed correction**.

INTREPID records proposed corrections for each correction method.

It keeps a 'running total' of proposed corrections in the **beta misclosure**.

A beta misclosure is constructed as a proposed alternative misclosure for the crossover. Therefore a 'blank' beta misclosure is equal in value to the original misclosure for the crossover.

© 2012 Intrepid Geophysics

Correction types

Immediate corrections

Immediate corrections involve applying a correction directly to all data. These correction do not require crossovers.

The immediate corrections are

- Heading
- Parallax
- Diurnal
- GRF

When you specify an immediate correction, INTREPID calculates and records the correction for each crossover, and adds the correction to the beta misclosure for the crossover. The proposed corrections are for your information only. INTREPID does not use them when applying the corrections.

Crossover-based corrections

Crossover-based corrections involve first calculating corrections for the crossovers, then interpolating them between the crossovers for the rest of the dataset.

The crossover-based corrections are

- Level XY,
- Polynomial levelling
- Loop closure
- Single gradient (alpha only, mainly for Rio)
- Tensor corrections

When you specify a crossover-based correction, INTREPID calculates and records a proposed correction for each crossover, and adds the proposed correction to the beta misclosures for the crossovers.

Proposed corrections and crossovers datasets

Crossovers datasets contain sets of proposed corrections. When you load a crossovers dataset, INTREPID will prompt you to specify which (if any) of its proposed corrections to retrieve.

If you retrieve a crossover-based proposed correction it becomes the current proposed correction for its correction type.

If you do not retrieve a crossover-based proposed correction, the corresponding correction type will have no current proposed correction.

Immediate proposed corrections are for information only in the crossovers dataset and have no effect on any immediate correction operation in this tool.

See Creating and Using Crossovers Datasets for further information about crossovers datasets.

When you choose Apply Corrections INTREPID uses the current proposed correction for each crossover-based correction type.

© 2012 Intrepid Geophysics

Clearing beta misclosures

The beta misclosure is a running total of the current proposed corrections. INTREPID does not use it in the correction process.

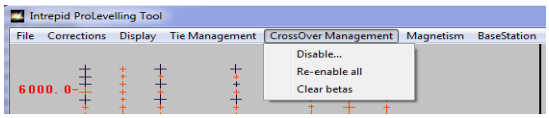
You can clear (i.e., set back to equal the original misclosure) beta misclosures from the dataset if you wish.

If you clear the beta misclosures, you will no longer have a running tally of the corrections made in the current session.

Clearing the beta misclosures has no effect on any proposed corrections or immediate correction specifications.

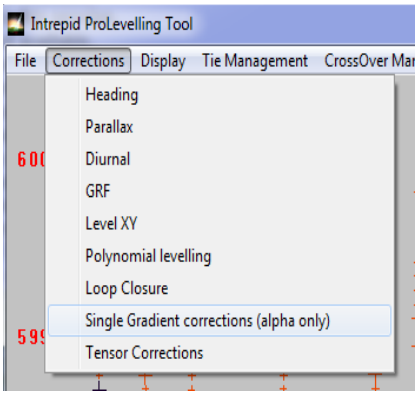
>> To clear the beta misclosures

Choose Clear betas from the Crossovers menu.



Levelling corrections—brief descriptions

INTREPID provides seven types of levelling correction for your data. You can see a list of them in the Corrections menu



Headings corrections *(Immediate)* Corrects errors due to aircraft or ship direction.

Parallax corrections *(Immediate)* Corrects errors in location of readings arising from the horizontal distance separating the acquisition instrument and the navigation instrument.

Diurnal corrections *(Immediate)* Corrects for diurnal variation in the background signal that occur over time and confound the readings. INTREPID compares the flight data with data collected at a base station during the same time interval.

GRF corrections *(Immediate)* Subtracts the intensity of the Earth's core magnetic field.

Level XY corrections *(Crossover-based)* Infers the correct location of a crossover point by extrapolating a line at the crossover point and seeking a point of intersection.

Polynomial levelling *(Crossover-based)* Levels the dataset by fitting the data to a curve along the tie lines, then along the flights and finally along each acquisition line.

© 2012 Intrepid Geophysics

Loop closure corrections *(Crossover-based)* Finds an optimum correction for each crossover using an iterative procedure.

Single Gradient corrections (alpha only and also Cross-over-based) Finds 3D Truncated Fourier series methods to attempt to recover the tensor from one of its parts. The VKc is Tzz - Tyy.

Tensor corrections (*Crossover-based*) Leads into a new space for a arnge of innovative tensor only methods to assist in levelling this data signal type.

Heading corrections—for errors due to aircraft direction

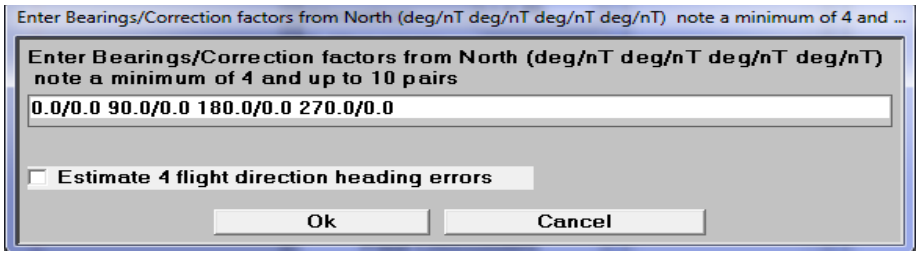
Due to a combination of the Earth's magnetic field and the permanent magnetisation of the sensing craft, measurements may slightly differ depending on the direction of travel. Compensation for scalar measurments have been turned into a “black-box” process over the years. This does not work for highjer order gradient measures, and a whole new invention of techniques is required to correct for Roll, Pitch and Yaw errors in the coming years.

Traditionally for a TMI scalar signal, after aircraft compensation, you can specify correction adjustments for four directions and add an adjustment to each data point according to the line direction. INTREPID calculates the correction for each direction using a smooth curve from 0°–360° passing through the correction parameters you have specified for the four directions. If you do not know how to estimate the Heading errors in this context, INTREPID [redacted]

The Heading correction alters the Signal values of the data. INTREPID

>> To specify the Heading correction,

1 Choose Headings from the Corrections menu. INTREPID displays the Headings corrections dialog box.


Enter Bearings/Correction factors from North (deg/nT deg/nT deg/nT deg/nT) note a minimum of 4 and ...
Enter Bearings/Correction factors from North (deg/nT deg/nT deg/nT deg/nT)
note a minimum of 4 and up to 10 pairs
0.0/0.0 90.0/0.0 180.0/0.0 270.0/0.0
Estimate 4 flight direction heading errors
Ok
Cancel

2 Enter four directions and the adjustment for each direction using the format *d/a d/a d/a d/a* where *d* is the direction in degrees from North, *a* is the adjustment in nanoTeslas (nT). For example

`0.0/2.0 90.0/3.0 180.0/0.0 270/-2.0`

3 Choose OK. INTREPID will note the corrections and apply them when you choose Apply Corrections.

Gradient Extensions

As it is difficult to see how you can specify a tensor heading correction in a simple manner, along the lines of a pop-up dialog box, INTREPID instead relies on the automatic estimation from statistics approach, for a Heading correction for a tensor / vector signal.

It is proposed that a Heading correction is in fact a compromised concept, and a Full Rotational levelling correction is the proper way to think of this class of systematic

© 2012 Intrepid Geophysics

error.

Parallax corrections—cable length

Acquisition instruments are usually in a different position to the navigation instrument. Parallax corrections involve a slight adjustment to the location of the data to allow for this positional effect.

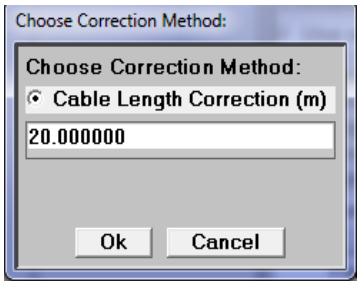
INTREPID will adjust all points to have a different location. It bases the new location on

- The reported geographic location (X and Y),
- The direction of travel,
- The separation of the instruments.

The Parallax correction alters the X and Y values of the data.

>> To specify Parallax corrections

1 Choose Parallax from the Corrections menu. INTREPID displays the Parallax corrections dialog box.



2 Enter the separation (in metres) into the Cable length text box.

3 Choose OK. INTREPID will note the corrections and apply them when you choose Apply Corrections.

Diurnal corrections

The background radiation or magnetism may fluctuate during surveys. These are called **diurnal** fluctuations, because they vary over a 24 hour period with some regularity. Some are attributable to sun spots. These fluctuations can occur during the course of a flight and so can confound your data.

To correct for this you can take readings from a nearby, stationary base station during the flight, synchronised by the fiducial clock. These readings will show only the diurnal fluctuations. If you subtract the base station readings from the flight data, you will remove the background errors.

The Diurnal correction alters the Signal values of the data. It requires a separate line dataset containing the base station data.

Base station—Survey data synchronisation methods

Before applying diurnal corrections INTREPID must be able to synchronise the dataset to be levelled with the base station dataset, matching the survey data with the correct base station data.

INTREPID provides synchronisation methods corresponding to your flight reconstruction method: Date / Time, Julian Day / Time and Flight / Fiducial

© 2012 Intrepid Geophysics

matching. See Chronological order—reconstructing the flights for details of this process.

Date / time synchronisation

If you reconstructed the flights using Date and time data, and the base station dataset has matching Date and time data, then you can use this data to synchronise the datasets.

Julian day / time synchronisation

If you reconstructed the flights using Julian day and time data, and the base station dataset has matching Julian day and time data, then you can use this data to synchronise the datasets.

© 2012 Intrepid Geophysics

Time matching options

As long as the results match properly (i.e., INTREPID can calculate matching internal Julian time fields from them), the two datasets involved can have any of the following.

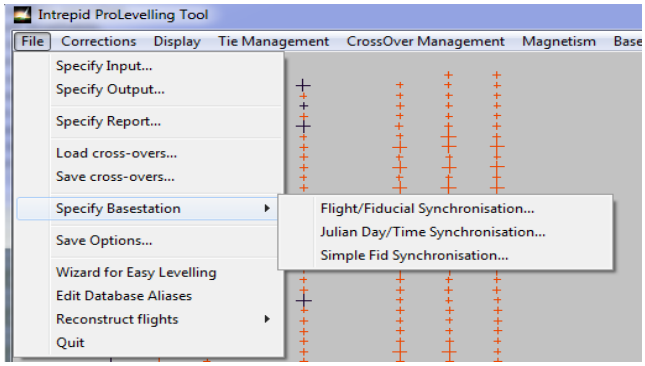
- A start time field and time calculated from fiducial numbers (**Fiducial** alias) and a fiducial factor (**FiducialFactor** alias),
- No start time field and time calculated from fiducial numbers (**Fiducial** alias) and a fiducial factor (**FiducialFactor** alias) (assuming fiducial 0 represents midnight at the start of the survey day),
- No start time field and a time field nominated as the fiducial field (**Fiducial** alias).

Flight/Fiducial synchronisation

If you reconstructed the flights using flight and fiducial numbers and the base station dataset has matching flight and fiducial numbers, you can use them to synchronise the datasets.

Specifying Diurnal corrections

>> To specify Diurnal corrections:



1 If you have not already done so, reconstruct the flights (See Chronological order—reconstructing the flights for full instructions).

2 Choose one of the options from the Specify Basestation cascade in the File menu.

(See Base station—Survey data synchronisation methods for an explanation of the Flight date/time and Julian day/time options.)

Date / Time / Fiducial Synchronisation

If you choose Date / Time / Fiducial INTREPID will prompt you to specify the Date, start time, fiducial and Signal fields of the base station dataset.

If the base station dataset has a time field with a time for each data point and you will be specifying this as the fiducial field, do not specify the same field as the start time field.

Julian Day / Time / Fiducial Synchronisation

If you choose Julian Day / Time / Fiducial INTREPID will prompt you to specify the Julian day, start time, fiducial and Signal fields of the base station dataset.

If the base station dataset has a time field with a time for each data point and you will be specifying this as the fiducial field, do not specify the same field as the start time field.

© 2012 Intrepid Geophysics

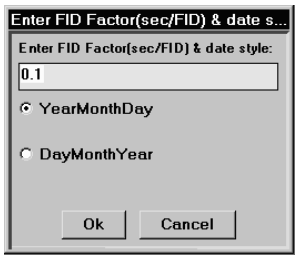
Flight / Fiducial Synchronisation

If you choose Flight / Fiducial Synchronisation INTREPID will prompt you to specify the flight number, fiducial and Signal fields of the base station dataset.

(See Specifying input and output files for general instructions about specifying files.)

3 If you specified Date / Time / Fiducial Synchronisation, INTREPID displays the Fid Factor and Date Format dialog box.

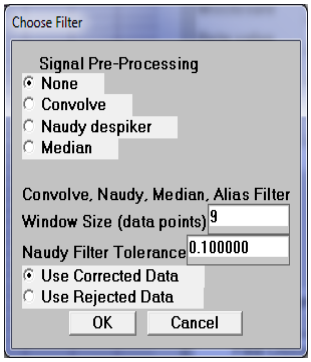
If you specified Julian Day / Time / Fiducial Synchronisation, INTREPID displays the Fid Factor dialog box.



Enter the fiducial factor. (This would normally be 1 if you assigned the time field to the **Fiducial** alias).

4 Specify the date format if required, then choose OK.

5 INTREPID displays the Signal field Pre-Process dialog box.



Select the process you require from the Pre-Process options. The default process is None.

Diurnal variations are predominately large wavelength phenomena with respect to time, and often base station data contain noisy spikes. We therefore recommend subtle pre-filtering of the diurnal magnetic data using either the Convolve (Fuller) or Naudy filters.

If you have selected Convolve (Fuller), specify the size of the convolution window in data points, using the Window Size (data points) text box. See "Fuller filter" in INTREPID spatial and time domain filters and transformations (R13) for further information.

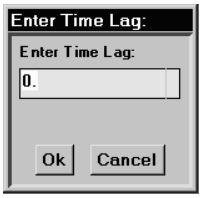
© 2012 Intrepid Geophysics

If you have chosen the Naudy filter, specify

- The filter wavelength (in data points) using the Window Size (data points) text box,.
- The filter tolerance (in Signal units) using the Tolerance text box,

See "Naudy filter" in INTREPID spatial and time domain filters and transformations (R13) for further information.

6 INTREPID displays the Enter Time Lag dialog box.



Enter the time lag in seconds and choose OK. See Time lag for an explanation.

7 Examine the base station data if required. You can do this at any time after loading base station data. See Examining base station data for instructions.

8 INTREPID will note the base station Signal field that you specified as corrections and apply them when you choose Apply Corrections.

Since base station data typically has only one data point for about 100 data points in the survey dataset, INTREPID will interpolate the corrections for the data points that do not have corresponding data points in the base station dataset.

Time lag

Some diurnal fluctuations occur quite rapidly and may be due to sunspot activity. This may be vary with the angle of the sun. If the base station is some distance from the survey area, the angle of the sun at a certain time during the survey will occur at a slightly different time at the base station due to the Earth's rotation.

You can specify the time difference in seconds between the base station and the central point of the survey area. Specify the difference in seconds, using a positive number if the base station is East of the survey area and a negative number if it is West.

Examining base station data

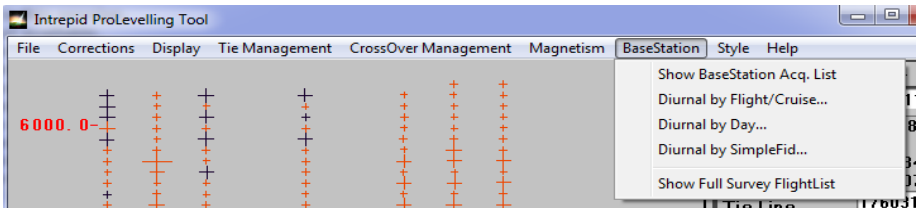
You can view the following base station data:

- A list of flights or julian days for which data exists in the base station dataset.
- A list of all flight numbers in the dataset being levelled.
- A profile graph of the base station Signal field for a given flight.
- A profile graph of the base station Signal field for a given date or julian day.

© 2012 Intrepid Geophysics

>> *To examine base station data*

1 Choose one of the options from the Base station menu



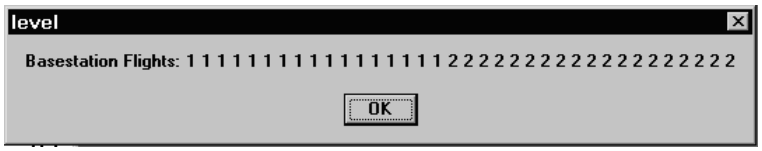
2 If you choose Display Flight/Cruise or Display Day, INTREPID will prompt you to enter the date or select the flight number or julian day. Specify the data required.

3 INTREPID displays the information you require.

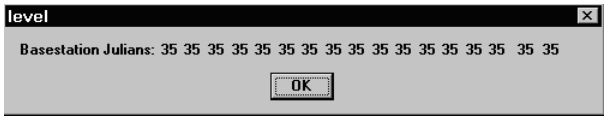
4 When you have finished viewing the information, choose OK.

Base station or Full Survey Flight list

If you choose Show Base Station Acquisition List. INTREPID displays a message box showing all of the flights or Julian days (depending on the synchronisation method) for which data exists in the base station dataset. Choose OK when you have finished viewing the list.



List of flights with data in the base station dataset



List of Julian days with data in the base station dataset

The numbers are repeated in these message boxes because INTREPID is listing the flight or Julian day for each group (corresponding to a traverse line) in the dataset.

If you choose Show Full Survey Flight List INTREPID displays the list in a message box. Choose OK when you have finished viewing the list.

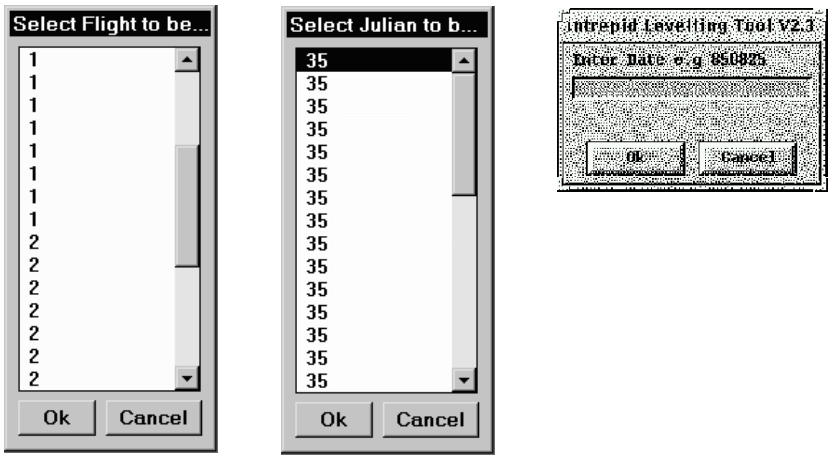
© 2012 Intrepid Geophysics

Flight/Cruise or Day profile graphs

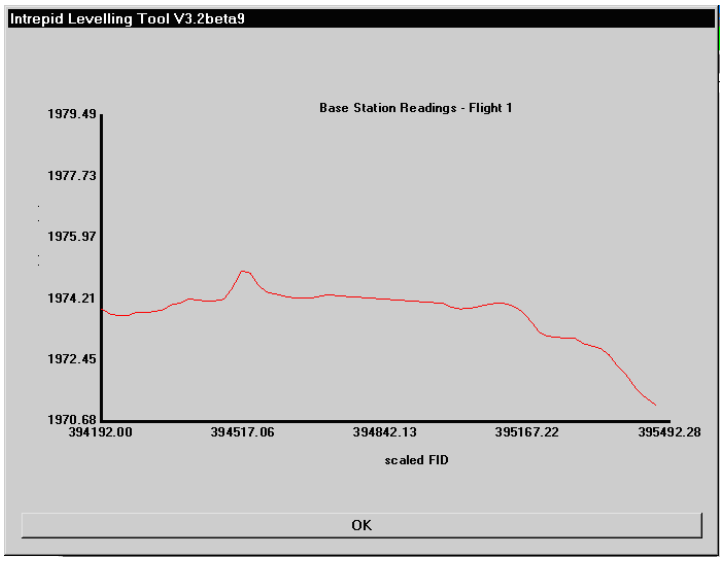
If you choose Display Flight/Cruise, INTREPID displays the Select Flights dialog box containing a list of the flights for which the base station dataset contains data. Select (click) the flight for the profile display, then choose OK.

If you choose Display Day and you are using Julian day/time synchronisation, INTREPID displays the Select Julians dialog box containing a list of the days for which the base station dataset contains data. Select (click) the flight for the profile display, then choose OK.

If you are using Flight/Fiducial synchronisation and choose Display Day INTREPID displays the Enter date dialog box. Enter the date for the profile in *yymmdd* format (e.g., 970221 for 21 February 1997), then choose OK.



INTREPID displays the flight or all flights for the day in a graph with Fiducial record on the horizontal axis.



Choose OK when you have finished viewing the graph.

© 2012 Intrepid Geophysics

GRF—Subtracting the Earth's core magnetic field

If you are levelling magnetic data, you will need to subtract the intensity of the Earth's core magnetic field using a Geomagnetic Reference Field (GRF) resource. See The geomagnetic reference field in INTREPID (R15) for an explanation of GRF. The correction will remove the influence of the Earth's core magnetic field. Luyendyk (1997)[1] gives a detailed explanation of the GRF correction.

Intrepid can calculate the GRF either by using a fixed survey date or a variable date. For a fixed date GRF, typically the survey date will be the mean survey date. For a variable date GRF, you must specify a date field in the Reconstruct flights (Date/time Fids) phase if you wish Intrepid to use it. In this case the date field will override the survey date defined in the GUI.

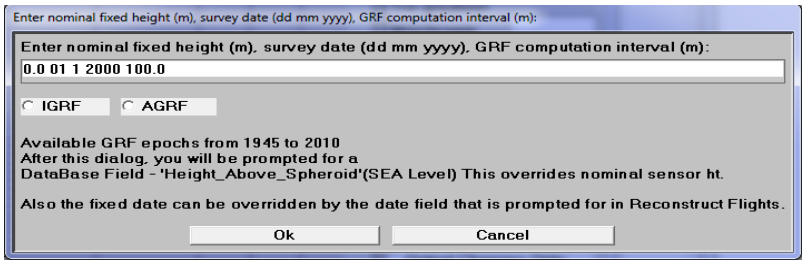
Intrepid can calculate the GRF using either a fixed elevation, or a variable elevation. For a fixed elevation GRF, typically the nominal fixed height will be the mean height of the sensor above sea level. For a variable elevation GRF, you must nominate a field that provides Intrepid with height data above the spheroid, eg: GPS height. In this case the height field will override the fixed height defined in the GUI.

The GRF correction alters the Signal values of the data.

The GRF field itself can be saved by clicking the Output Changes Only box, on the right hand side of the tool. In this case the specified output field will contain the calculated GRF.

>> *To specify the GRF correction*

1 Choose GRF from the Corrections menu. INTREPID displays the GRF Corrections dialog box.


Enter nominal fixed height (m), survey date (dd mm yyyy), GRF computation interval (m):
Enter nominal fixed height (m), survey date (dd mm yyyy), GRF computation interval (m):
0.0 01 1 2000 100.0
IGRF
AGRF
Available GRF epochs from 1945 to 2010
After this dialog, you will be prompted for a
DataBase Field - 'Height_Above_Spheroid'(SEA Level) This overrides nominal sensor ht.
Also the fixed date can be overridden by the date field that is prompted for in Reconstruct Flights.
Ok
Cancel

2 Enter the mean sensor height[2] ASL (in metres), survey date (in the format *dd mm yyyy*) and the GRF computation interval (in metres) in the parameters text box.

3 Choose IGRF (International) or AGRF (Australian) using the IGRF / AGRF option buttons.

4 Choose OK. Intrepid will display a chooser requesting a field containing height above spheroid data. If you wish to compute a variable elevation GRF, select the field and click OK. If you wish to compute a fixed elevation GRF using the nominal sensor height, click Cancel.

5 Choose OK. INTREPID will note the corrections and apply them next time you choose Trial Corrections or Apply Corrections.

---

1. op. cit., p. 33
2. This may be any measure of sensor height. See Using different height measures for details.

© 2012 Intrepid Geophysics

GRF Parameters

Survey date and height, AGRF / IGRF See The geomagnetic reference field in INTREPID (R15) for an explanation of these parameters. [1]

GRF computation interval Since the GRF field varies very slowly within surveys, a single correction applied to a number of points within one line segment may be accurate enough instead of calculating the GRF for all points. The GRF computational interval is the length of the line segment for which a single GRF correction value will suffice.

The computation interval need not be small. INTREPID calculates the GRF correction for the centre point of each interval. It then interpolates individual corrections for each data point between the centre points. The default of every 100 m is reasonable. We recommend that this interval be not more than 1/3 of the line length.

Of course, if measuring magnetic tensor data, a GRF correction is not likely to be needed, as a gradient measure does not contain any Common Mode signal, or another way of saying it, the GRF is differenced out of the signal.

Level XY corrections—inferring the correct location

Two readings on the same location with diurnal and parallax corrections applied should be the same. If there is a non-zero misclosure for a crossover point it could be the result of an error in the measurement of location.

Now that we use GPS navigation, the degree and frequency of this error is vastly reduced. Non-zero misclosures are more likely due to problems with acquisition height.

In the Level XY correction process, INTREPID searches for the true location of the crossover point by trying to find a position nearby where extrapolated crossover values are the same for the tie line and the acquisition line. To search for this point INTREPID uses the gradients that it calculated for the tie line and the acquisition line at the crossover point. INTREPID adjusts the line with the highest crossover gradient (the **higher gradient line**). As this is a positional adjustment, there is nothing special required for tensors??

Theory of the Level XY correction

1. The readings near the crossover on the higher gradient line may have been attributed to the wrong location due to navigational errors.
2. The location of readings near the crossover on the other line may be more accurate.
3. By a process of extrapolation you can estimate values at other locations near the measured crossover point in the higher gradient line.
4. The best direction and method of extrapolation is to change X, Y and Signal values in a direction along a straight line with the following characteristics:

- It passes through the higher gradient crossover point;
- It has a gradient equal to the crossover gradient;
- The direction makes the higher gradient crossover Signal value approach the

1. This may be any measure of sensor height. See Using different height measures for details.

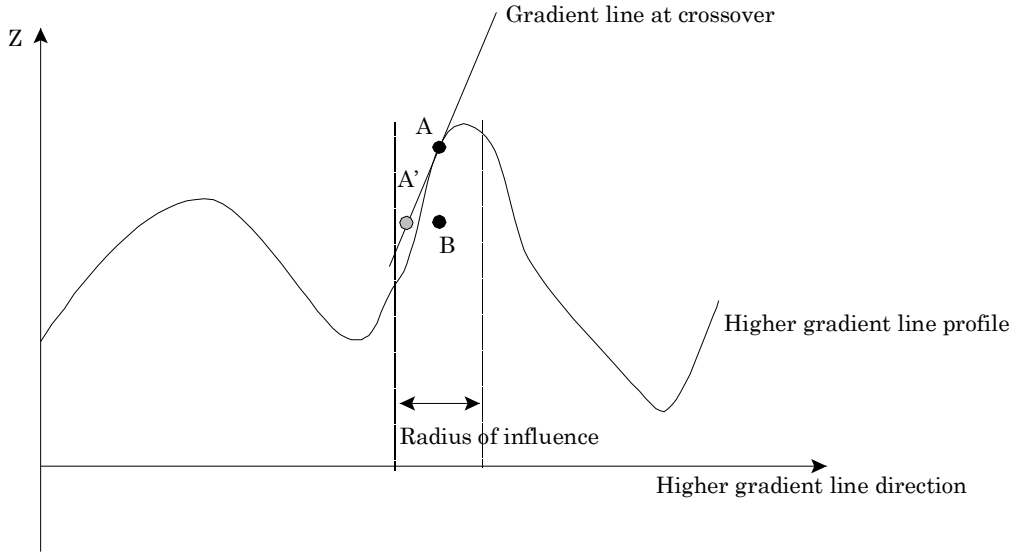
© 2012 Intrepid Geophysics

corresponding crossover Signal value in the other line.

© 2012 Intrepid Geophysics

5 Within a radius that you have set as a limit, you may find a point on this extrapolation line where the Signal value is equal to the other crossover Signal value (**zero misclosure**). Adopt this new point as the correct crossover point. This involves changing the X, Y and Signal values of the crossover.

XY Level Correction Process



A – Original crossover point on higher gradient line
B – Original crossover point on other line (direction perpendicular to page surface in this diagram)
A'– New crossover point on higher gradient line with zero misclosure

Using the Level XY correction

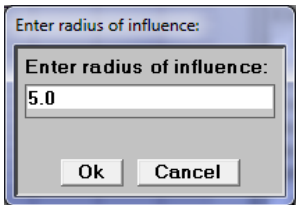
The Level XY correction alters the X, Y and Signal values of the data.

>> To use the Level XY corrections

1 If you have not already done so,

- Perform Parallax, Diurnal and GRF[1] corrections as required, then commence a new Levelling session,
- Reconstruct the flights,
- Calculate the crossovers for the dataset.

2 Choose Level XY from the Corrections menu. INTREPID displays the Level XY radius of influence dialog box.



3 The radius of influence is the radius (in metres) within which INTREPID may extrapolate along the gradients searching for points of zero misclosure. Enter the required radius of influence in the text box.

1. You may perform Diurnal and GRF corrections simultaneously with the Level XY correction if you do not need to examine their results before proceeding.

© 2012 Intrepid Geophysics

4 Choose OK. INTREPID will calculate proposed corrections for all enabled crossovers. It can display the proposed corrections as line vectors in the dataset display area (See Crossover and line display options for instructions).

Polynomial levelling

You can use the Polynomial correction technique to eliminate the effects of instrument drift and gross levelling errors. The technique involves fitting a polynomial curve through the misclosures along the tie lines, then along the flights and finally along each acquisition line.

This method uses as a starting point the tie line that you consider to be the most level (i.e., with the smallest average misclosure and the smallest variation in misclosures). INTREPID uses this tie line (the **principal tie line** to detect errors in other tie lines and in acquisition lines.

The Polynomial levelling correction alters the Signal values of the data.

Choosing the principal tie line and the tie line order

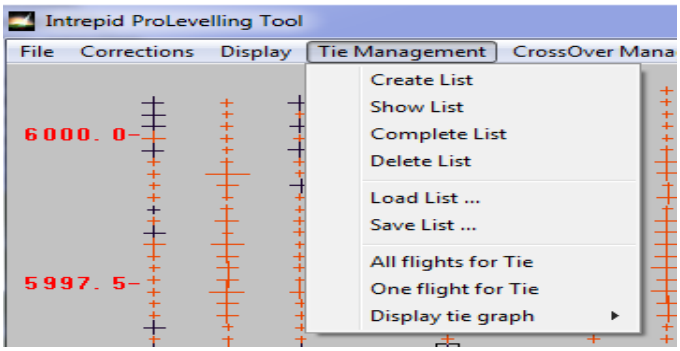
To prepare for the polynomial corrections you must choose the principal tie line, then determine the order in which the rest of the tie lines will be processed. You can choose one or more further tie lines after the first that you consider to be reasonably level. INTREPID will use them after the initial tie line. INTREPID will then automatically select the rest of the tie lines in sequence.

To assist you to select the most level tie line, INTREPID can display data for crossovers along a tie line in a variety of ways.

See Crossover and line display options and Displaying profiles along individual tie lines for instructions.

>> To create the tie line calculation list

1 Choose Create List from the Tie Line menu.



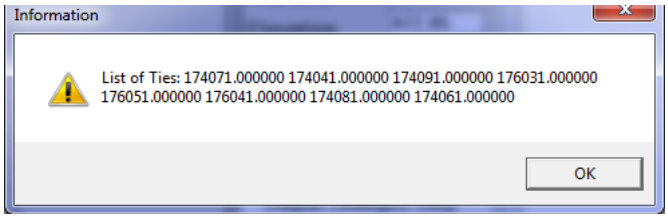
2 Click once any point or crossover of the most level tie line in the dataset display area. INTREPID will record it as the first tie line for calculation.

3 Click once any subsequent tie lines you wish to individually select. INTREPID will record them.

4 Choose Complete List from the Tie Line menu. INTREPID will create the rest of the list automatically.

© 2012 Intrepid Geophysics

5 Display the list to check that it has been constructed properly. choose Show List from the Tie Line menu. INTREPID displays the list in a message box. This example is from Albury.



6 Choose OK when you have finished viewing the list.

7 Save the tie line list for subsequent leveling sessions with this dataset if required.

>> To clear the tie line list,

Choose Delete List from the Tie Line menu.

Tie line list files

You can store tie line lists as text files for use in batch mode tasks or later sessions.

If you will be executing a task in batch mode using a tie line list, you must create a tie line list file.

Here is an example of tie line list file, which could have the name **`eba_tie.parm`**.

```
TieList Begin
   List = {
             7122
             7111
             7121
   }
TieList End
```

>> To save the current tie line list

Choose Save List from the Tie Line menu. INTREPID displays the Save List dialog box. Locate the directory for the list file if necessary. Specify the name for the list file (INTREPID will automatically add the extension **`.parm`**) and choose Open.

>> To load an existing tie line list

If the tie line list you require already exists as a tie line list (**`.parm`**) file, choose Load List from the Tie Line menu. INTREPID displays the Load List dialog box. Locate the directory for the list file if necessary. Select (click) the file required and choose Open.

© 2012 Intrepid Geophysics

The Polynomial 'drift estimation' levelling method

Drift curves

The polynomial levelling method involves the calculation of least squares fit along flights, tie lines and acquisition lines. These curves plot misclosure (differences between Signal values in tie lines and acquisition lines) against time.

Modern magnetometers do not have significant changes in accuracy with time, but the readings are subject to other sources of error such as diurnal variations. Radiometric data are also subject to various errors, such as the changing of energy windows boundaries with temperature. Whatever the source of errors we refer to them as **instrument drift**, or simply **drift**. And assume that they can be approximated as a function of time by a piecewise polynomial (the so-called **drift curves**).

Whatever the source of drift, provided that the basic polynomial approximation assumption holds, the polynomial levelling method is an effective technique for cross referencing acquisition and tie line data and systematically apportioning the misclosure between the acquisition and tie lines.

Steps in polynomial levelling

Polynomial levelling has up to four stages:

1. Level the tie lines assuming that the principal tie line has no errors,
2. Correct each flight assuming that the tie lines are correct

   This step is sometimes described as 'Drifting the acquisition lines by flight to the tie lines'.
3. Correct the individual acquisition lines assuming that the tie lines are correct.

   This step is sometimes described as 'Drifting the acquisition lines individually to the tie lines'.
4. Correct the individual tie lines again assuming that the acquisition lines are correct. This is an optional step intended to remove any last residual errors.

   This step is sometimes described as 'Drifting the tie lines individually to the acquisition lines'.

Stage 1: Levelling the tie lines

1. We select the principal tie line. It should have the following characteristics:

- 'It should be one that was flown during a period of quiet diurnal activity,
- Be located over a region of low magnetic relief, and
- Be located approximately at the centre of the survey region.' [1]

2. INTREPID creates a polynomial function f(fid) along a flight. The function's curve is a least squares fit of the misclosures on the principal tie line. We assume that the principal tie line contains no levelling errors, so this curve represents acquisition line-only errors.

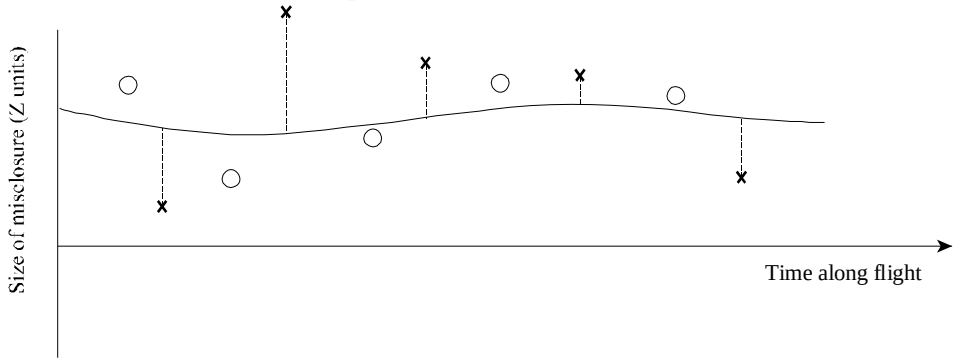
1. Luyendyk, A. P. J., op. cit., p.35 (Bullets added)

© 2012 Intrepid Geophysics

3 INTREPID examines the second tie line's misclosures and records their offsets from the curve created in step 2. Since the curve represents acquisition line-only error, these offsets must be errors in the tie line Signal values for the second tie line.

Levelling of tie line data – Step 1

First estimate of the acquisition line-only error curve



○ Misclosures on principal tie line

× Misclosures on second tie line

Errors due to tie line Z value (offsets from acquisition line-only error curve)

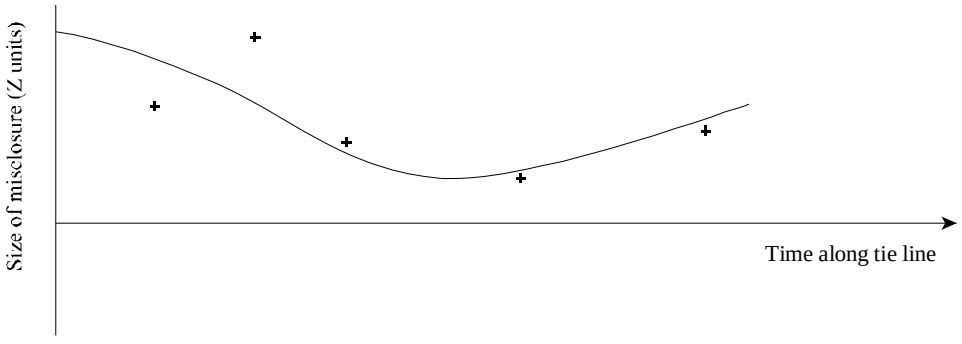
The curve is calculated by least squares fit to misclosures on the principal tie line (points marked ○).
Since the principal tie line Z values are assumed to have no error, the curve represents the errors due to acquisition line Z values only.
The deviation of the second tie line misclosures from this curve must be due to errors in the second tie line Z values. We can record these errors and use them to correct the second tie line Z values.

INTREPID repeats step 2 and 3 for all flights with acquisition lines crossing the principal tie line. In this way it collects a complete set of corrections for the second tie line.

4 INTREPID corrects the second tie line Signal values for the errors determined in step 3. It does this by calculating a least squares fit curve for the errors along the tie line. It then uses values on the curve as sources for the tie line Signal values corrections.

Levelling of tie line data – Step 2

Correction curve for tie line Z values



+ Error due to tie line Z value (size of offset from acquisition line-only error curve)

The curve is calculated by least squares fit to the tie line errors and represents the errors due to tie line Z values on this tie line. It is the source of correction for levelling the tie line.

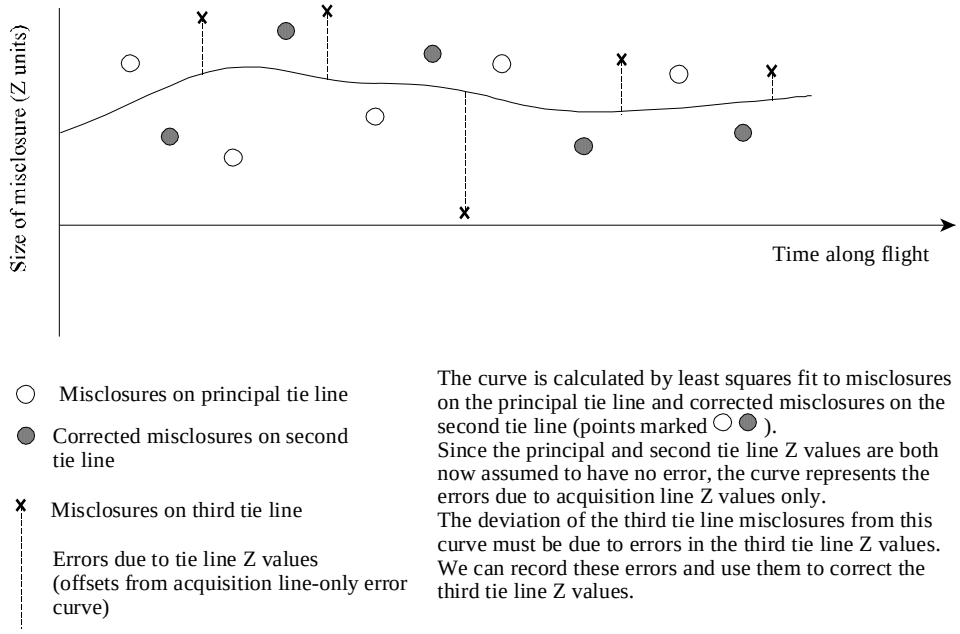
© 2012 Intrepid Geophysics

5 INTREPID uses the principal tie line Signal values and the corrected second tie line Signal values to calculate a new curve along a flight. This is based on more data and is therefore a better estimate of the acquisition line only errors for the flight.

6 INTREPID examines the third tie line's misclosures records their offset from the curve created in step 6. Since the curve represents acquisition line-only error, these offsets must be errors in the tie line Signal values for the third tie line.

Levelling of tie line data – Step 3

Second estimate of the acquisition line-only error curve


Size of misclosure (Z units)
Time along flight
Misclosures on principal tie line
Corrected misclosures on second tie line
Misclosures on third tie line
Errors due to tie line Z values (offsets from acquisition line-only error curve)
The curve is calculated by least squares fit to misclosures on the principal tie line and corrected misclosures on the second tie line (points marked ○ ●).
Since the principal and second tie line Z values are both now assumed to have no error, the curve represents the errors due to acquisition line Z values only.
The deviation of the third tie line misclosures from this curve must be due to errors in the third tie line Z values.
We can record these errors and use them to correct the third tie line Z values.

INTREPID repeats step 6 and 7 for all flights with acquisition lines crossing the principal tie line. In this way it collects a complete set of corrections for the third tie line.

7 INTREPID corrects the third tie line Signal values for the errors determined in step 7. It does this in the same way as it did with the second tie line in step 5.

8 INTREPID repeats steps 6–9 including the corrected third tie line in the calculation of the acquisition line-only error curve and calculating corrections for the 4th tie line. It continues in this way until it has corrected all of the tie lines.

Stage 2: Levelling the flights

Having levelled the tie lines we may now assume that the remaining misclosures are due to acquisition line errors. INTREPID calculates a least squares fit curve for the misclosures along the flight and uses it as a source for the corrections to the acquisition line Signal values in the flight.

For a diagram of this operation refer to the diagram of step 2 in the tie line levelling stage above.. The flight correction is similar except that you are calculating the curve along the flight instead of the tie line.

This step is sometimes described as 'Drifting the acquisition lines by flight to the tie lines'.

If your dataset has no flight number field, you must omit this step.

© 2012 Intrepid Geophysics

Stage 3: Levelling the individual acquisition lines

After we have levelled the flights there may still be some residual errors that are line-specific (e.g., heading errors (See Heading corrections—for errors due to aircraft direction for a description of these errors)). INTREPID calculates least squares fit curves for the misclosures along each line and uses then as sources for the corrections to their respective acquisition line Signal values.

For a diagram of this operation refer to the diagram of step 2 in the tie line levelling stage above.. The acquisition line correction is similar except that you are calculating the curve along the acquisition line instead of the tie line.

This step is sometimes described as 'Drifting the acquisition lines individually to the tie lines'.

Stage 4: Levelling the individual tie lines again

After we have levelled the individual acquisition lines there may be some remaining residual errors in the tie line Signal values. If you perform this step, INTREPID calculates least squares fit curves for the misclosures along each tie line and uses then as sources for the corrections to their respective tie line Signal values.

For a diagram of this operation refer to the diagram of step 2 in the tie line levelling stage above.

This step is sometimes described as 'Drifting the tie lines individually to the acquisition lines'.

Additional information about polynomial levelling

- INTREPID can weight the contribution of crossover point Signal values in calculating the polynomial for the curve according to their estimated stability. See Crossover weighting methods for details of the weighting methods available.
- INTREPID uses a piecewise low order polynomial for the curve in the process.

Using the Polynomial levelling process

>> To use Polynomial levelling

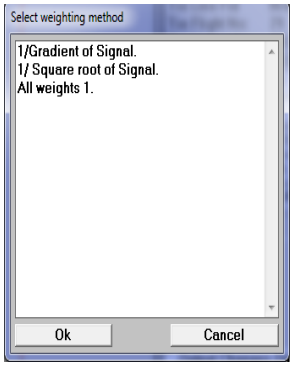
1 If you have not already done so,

- Perform Parallax, Diurnal and GRF[10] corrections as required, then commence a new Levelling session,
- Reconstruct the flights,
- Calculate the crossovers for the dataset,
- Create a lie line list. (See Chronological order—reconstructing the flights for full instructions).

1.[0] You may perform Diurnal and GRF corrections simultaneously with the Polynomial levelling if you do not need to examine their results before proceeding.

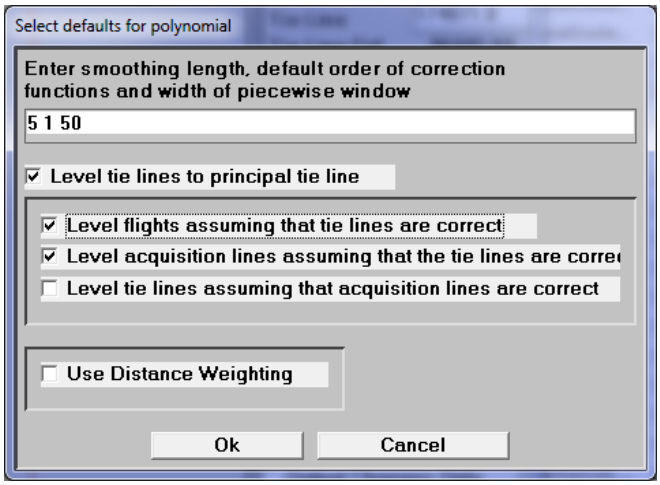
© 2012 Intrepid Geophysics

2 Choose Polynomial from the corrections menu. INTREPID displays the Select Weighting Method dialog box. Generally for TMI you should pick an inverse of the gradient of the Signal. The rationale is that in high gradient regions, the error is likely to be exaggerated. For radiometrics signals, the usual advice is to suggest the inverse of the square root of the signal, as the weighting. If you do not want any bias, just choose all weights set to 1.



3 Select (click) the weighting method you wish to use, then choose OK. See Crossover weighting methods for details about weighting methods.

4 INTREPID displays the Select Defaults for Polynomial dialog box.


Select defaults for polynomial
Enter smoothing length, default order of correction functions and width of piecewise window
5 1 50
Level tie lines to principal tie line
Level flights assuming that tie lines are correct
Level acquisition lines assuming that the tie lines are corre
Level tie lines assuming that acquisition lines are correct
Use Distance Weighting
Ok
Cancel

5 Enter the initial smoothing length, default order of correction functions and the width of the piecewise window. See Polynomial levelling for details.

6 Turn on check boxes corresponding to the polynomial levelling stages you wish to perform. See Selecting polynomial levelling process stages for details. A new distance weighting option has been introduced, largely for marine levelling situations, where the sampling intervals can be very different. You do not want equal weight given to a signal measured at a far distance to the current cross-over, compared to a much more local reading. This is unlikely to be needed for standard airborne surveying. Choose OK.

© 2012 Intrepid Geophysics

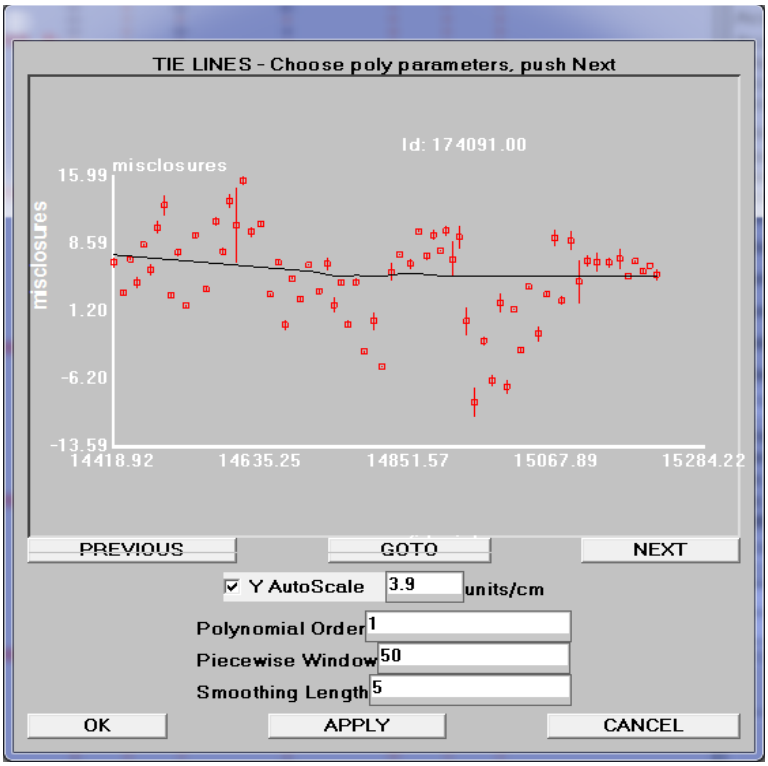
Levelling the tie lines assuming that the principal tie line is correct

7 If the Level Tie Lines to Principal Tie Line check box in the Select Defaults for Polynomial dialog box was off, go to the next step.

INTREPID displays a panel for the first selected stage of levelling (tie lines) with the parameters you defined in steps 5 and 6.

Choose Apply to calculate the first polynomial.

INTREPID displays the curve with the crossover misclosure values of the second tie line. The offsets of the misclosures from this curve represent tie line errors, which INTREPID proposes to correct, creating new tie line Signal values.



The horizontal axis of the graph represents time in seconds or fiducial numbers from the beginning of the line (depending on the basis of the flight reconstruction). The vertical axis represents the misclosure (difference between acquisition and tie line values in Signal units).

The graph shows the crossover errors as small squares, the polynomial as a single line curve and the weight assigned to the crossover as a vertical line through the square. The longer the vertical line, the bigger the gradient value, and so the smaller the weight applying to this mis-closure.

You can

- Without changing the parameters, view the results for the next or previous tie line or a tie line you choose from a list. (Choose **Next, Previous** or **Go To**.)
- Specify automatic or manual Y axis scaling for the graph. (Turn the Y Auto Scale check box on or off. If you turn Auto Scale off, specify the scale in Signal units / cm in the Scale text box.)
- Change the Polynomial Order, Piecewise Window or Smoothing Length parameters for the next curve calculation (See Polynomial levelling parameters for details about the purposes of these parameters).

© 2012 Intrepid Geophysics

- Recalculate the curve for the current tie line using the currently displayed parameters and display the results. (Choose **Apply**). INTREPID only recalculates results for the current tie line at this time.
- If you have changed the parameters, recalculate the curve for the current tie line, then recalculate and view the results for the next or previous tie line or a tie line you choose from a list. (Choose **Next, Previous** or **Go To**.) INTREPID only recalculates results for tie lines whose graphs you view.
- Recalculate the curve and corrections for the current tie line and all tie lines that follow it in the list, then commence the next levelling stage. (Choose **OK)**.

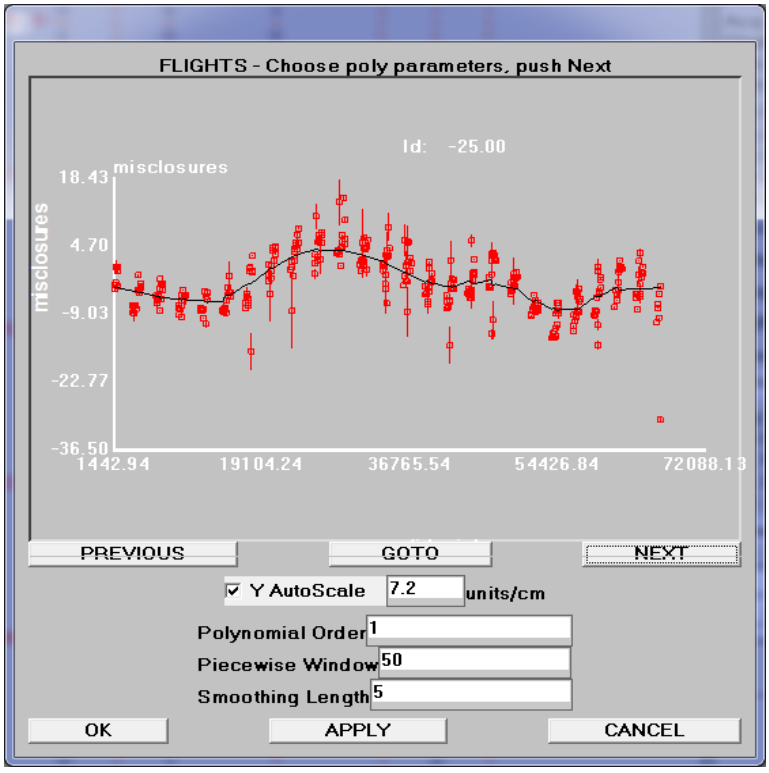
  Note: According to the tie line levelling method, the corrections for each tie line depend on the corrections for the previous tie line. INTREPID, however, does not automatically recalculate all of the corrections for tie lines later in the list if you change the parameters for one of the tie lines. When INTREPID calculates the polynomial and corrections for a tie line, it always uses the set of existing corrections for earlier tie lines at the time it is performing the calculation.

Levelling the flights assuming that the tie lines are correct

8 If the Level Flights Assuming that the Tie Lines are Correct check box in the Select Defaults for Polynomial dialog box was off go to the next step.

INTREPID displays a panel for the next selected stage of levelling (flights). Choose Apply to calculate the polynomial for the first flight using the misclosures (corrected by the tie line levelling process if performed (Step 7)). Under the assumptions of polynomial levelling, this curve represents acquisition line error only.

INTREPID displays the curve with the crossover misclosure values (corrected so far) of the first flight. The offsets of the misclosures from this curve represent acquisition line errors in the flight, which INTREPID proposes to correct, creating new acquisition line Signal values.



© 2012 Intrepid Geophysics

The horizontal axis of the graph represents time in seconds or fiducial numbers from the beginning of the flight (depending on the basis of the flight reconstruction). The vertical axis represents the misclosure (difference between acquisition and tie line values in Signal units).

The graph shows the crossovers as small squares, the polynomial as a single line curve and the weight assigned to the crossover as a vertical line through the square.

You can

- Without changing the parameters, view the results for the next or previous flight (in flight reconstruction order) or a flight you choose from a list. (Choose **Next, Previous** or **Go To**.)
- Specify automatic or manual Y axis scaling for the graph. (Turn the Y Auto Scale check box on or off. If you turn Auto Scale off, specify the scale in Signal units / cm in the Scale text box.)
- Change the Polynomial Order, Piecewise Window or Smoothing Length parameters for the next curve calculation (See Polynomial levelling parameters for details about the purposes of these parameters).
- Recalculate the curve for the current flight using the currently displayed parameters and display the results. (Choose **Apply**).
- If you have changed the parameters, recalculate the curve for the current flight, then recalculate and view the results for the next or previous flight (in flight reconstruction order) or a flight you choose from a list. (Choose **Next, Previous** or **Go To**.)
- Recalculate the curve and corrections for the current flight and all flights that follow it in the flight reconstruction order, then commence the next levelling stage. (Choose **OK**).
- Turn individual crossovers off or on (See Excluding crossovers from the levelling calculation for instructions.

Levelling the acquisition lines assuming that the tie lines are correct

9 If the Level Acquisition Lines Assuming that the Tie Lines are Correct check box in the Select Defaults for Polynomial dialog box was off, go to the next step.

INTREPID will calculate the polynomial for the first acquisition line(s) using the misclosures (corrected by the tie line and/or flight levelling process(es) if performed (Steps 7 and/or 8)). Under the assumptions of polynomial levelling, this curve represents acquisition line error only.

INTREPID displays the curve with the crossover misclosure values (corrected so far) of the first acquisition line. The offsets of the misclosures from this curve represent acquisition line errors in the flight, which INTREPID proposes to correct, creating new acquisition line Signal values.

The graph is similar to that shown in steps 7 and 8 and shows the crossovers as small squares, the polynomial as a single line curve and the weight assigned to the crossover as a vertical line through the square.

You can perform the same set of operations during the acquisition line levelling stage as during the flight levelling process. See step 8 above for a list of possible operations, substituting 'acquisition line' for 'flight'.

© 2012 Intrepid Geophysics

Levelling the tie lines assuming that the acquisition lines are correct

10 If the Level Tie Lines Assuming that the Acquisition Lines are Correct check box in the Select Defaults for Polynomial dialog box was off, go to the next step.

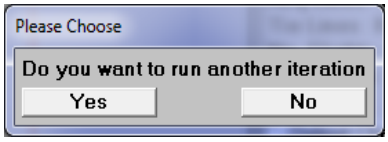
INTREPID will calculate the polynomial for the first tie line using the misclosures (corrected by the tie line and/or flight and/or acquisition line levelling process(es) if performed (Steps 7 and/or 8 and/or 9)). To be performing this step you will normally have performed steps 8 and/or 9. If this is the case, then under the assumptions of polynomial levelling, this curve represents any residual tie line error after the acquisition line levelling process.

INTREPID displays the curve with the crossover misclosure values (corrected so far) of the first tie line. The offsets of the misclosures from this curve represent tie line errors in the flight, which INTREPID proposes to correct, creating new tie line Signal values.

The graph is similar to that shown in steps 7 and 8 and shows the crossovers as small squares, the polynomial as a single line curve and the weight assigned to the crossover as a vertical line through the square.

You can perform the same set of operations during the tie line levelling stage as during the flight levelling process. See step 8 above for a list of possible operations, substituting 'tie line' for 'flight'.

11 INTREPID displays the Repeat Iteration dialog box.



INTREPID can repeat the whole Polynomial correction process using the current set of corrected crossovers, creating a more levelled result. If you require this, choose Yes, otherwise No.

If you choose Yes, INTREPID will go back to step 7.

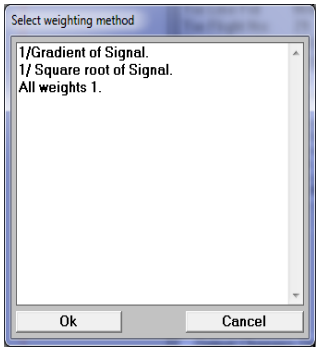
12 Repeat steps 7–11 as often as you require.

13 INTREPID will calculate proposed corrections for all enabled crossovers. It can display the proposed corrections as colours or red/black crosses in the dataset display area (See Display style—markers vs colours and Crossover and line display options for instructions). INTREPID can also display a profile of proposed polynomial levelling corrections along any tie line (See Displaying profiles along individual tie lines for details).

© 2012 Intrepid Geophysics

Crossover weighting methods

The stability of crossover data can vary. All data is subject to noise which causes rapid fluctuations in the Signal values. High frequency Signal data is an indicator of noise. You can assign weights to crossover data when calculating the polynomial so that less stable data has less influence on the polynomial calculation.



When you commence the polynomial levelling process (See Step 2 in Section Using the Polynomial levelling process), INTREPID prompts you to specify the weighting method, using the Select Weighting Method dialog box.

In assigning weights INTREPID examines the Signal value of the line that it is correcting (i.e., the tie line for stages 1 and 4 and the acquisition line for stages 2 and 3 in Section Using the Polynomial levelling process.

INTREPID has three weighting method options:

Gradient of Signal If you select this option INTREPID will assign a lower weight to crossovers with high gradient Signal values before calculating the polynomial. High gradient crossovers will contribute less than crossovers with a low gradient. Use this method with magnetic data. For magnetic data the gradient of Signal corresponds to the stability of the data.

$$\text{weight} = \frac{1}{e^{(0.1 \times \text{gradient})}}$$

Square root of Signal If you select this option INTREPID will assign weights to crossovers according to the square root of the Signal value. High Signal value crossovers will contribute less than crossovers with a low Signal value. Use this method with radiometric data. For radiometric data the square root of the Signal value corresponds to the standard deviation and indicates the stability of the data.

$$\text{weight} = \sqrt{Z}$$

All Weights 1 If you select this option INTREPID assigns weight 1 to all crossover values.

© 2012 Intrepid Geophysics

Polynomial levelling parameters

When you commence a polynomial levelling process (See Step 4–5 in Section Using the Polynomial levelling process) and for each line or flight at each stage of the process (See Steps 7, 8, 9, 10) you can specify the order of the polynomial function, the width of the piecewise window and the smoothing length.

Polynomial order (Default Order of Correction Functions) This parameter determines the order of the piecewise polynomial. The default order is 3.

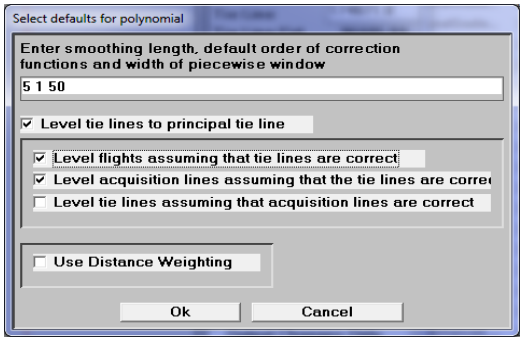
Piecewise window size This parameter determines the number of adjacent crossovers to use in computing the piecewise polynomial for a section of a line. The default value is 50.

Smoothing length The polynomial fit may be poor at the ends of a line or flight, so INTREPID applies a smoothing filter in this region. This parameter determines the number of crossovers at the end of the line or flight to which INTREPID apples the smoothing filter. The default value is 5.

Selecting polynomial levelling process stages

You can specify the polynomial levelling stages for INTREPID to perform. Each stage can be performed independently. If you omit an earlier stage, you are assuming that it is not necessary.

When you commence polynomial levelling (See Step 4, 6 in SectionUsing the Polynomial levelling process), INTREPID prompts you to select the levelling stages to perform using the Select Defaults for Polynomial dialog box.


Select defaults for polynomial
Enter smoothing length, default order of correction functions and width of piecewise window
5 1 50
Level tie lines to principal tie line
Level flights assuming that tie lines are correct
Level acquisition lines assuming that the tie lines are corre
Level tie lines assuming that acquisition lines are correct
Use Distance Weighting
Ok
Cancel

Level Tie Lines to Principal Tie Line Turn this check box on if you wish to level the tie lines assuming one tie line is correct. (See Stage 1: Levelling the tie lines and Step 7 in Using the Polynomial levelling process for details.)

Level Flights Assuming that the Tie Lines are Correct Turn this check box on if you wish to level the flights, assuming that the tie lines are correct. If your dataset has no flight number field, you must turn off the check box for this step. (See Stage 2: Levelling the flights and Step 8 in Using the Polynomial levelling process for details.)

Level Acquisition Lines Assuming that the Tie Lines are Correct Turn this check box on if you wish to level the acquisition lines, assuming that the tie lines and flights are correct. (See Stage 3: Levelling the individual acquisition lines and Step 9 in Using the Polynomial levelling process for details.)

Level Tie Lines Assuming that the Acquisition Lines are Correct Turn this check box on if you wish to level the tie lines, assuming that the acquisition lines are correct. (See Stage 4: Levelling the individual tie lines again and Step 9 in Using the Polynomial levelling process for details.)

© 2012 Intrepid Geophysics

Improving the polynomial fit at line and flight ends

At the ends of lines or flights the fit of the polynomial may be poor, because 'there is no constraint on the polynomial beyond the limits of the data and they may diverge from the expected result'[1].

To help remedy this, INTREPID applies a smoothing filter at the ends of the lines or flights. You can determine the number of crossovers to be filtered using the Smoothing Length parameter (See Polynomial levelling parameters).

If the ends of the tie lines 'whip' out of control in this way, try the following (in order of preference):

1. Change the piecewise window size (See Polynomial levelling parameters),
2. Reduce the polynomial order if it is greater than 4 (See Polynomial levelling parameters), and
3. Vary the tie line order for the tie line levelling process (See Choosing the principal tie line and the tie line order).

Loop closure levelling

The loop closure method repeatedly adjusts the Signal values in the acquisition lines to minimise overall misclosure for the dataset and distribute the residual errors. This method is simple and fast to use but results may be unstable in high gradient areas.

>> To specify loop closure correction.

1. If you have not already done so and it is appropriate,

- Perform Parallax, Diurnal and GRF[2] corrections as required, then commence a new Levelling session,
- Reconstruct the flights,
- Calculate the crossovers for the dataset.

2. Choose Loop closure from the Corrections menu. INTREPID will calculate proposed corrections for all enabled crossovers. It can display the proposed corrections as colours or red/black crosses in the dataset display area (See Display style—markers vs colours and Crossover and line display options for instructions).

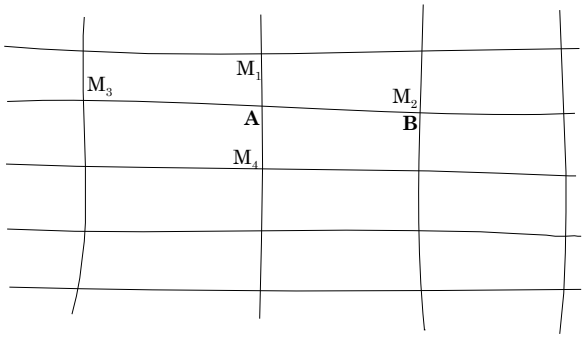
1.[1] Luyendyk, A. P. J., op. cit., p.36

2.[2] You may perform Diurnal and GRF corrections simultaneously with the Loop closure levelling if you do not need to examine their results before proceeding.

© 2012 Intrepid Geophysics

The loop closure process

The loop closure process is described in detail by Green (1983)[1]



A set of acquisition and tie line form a 'grid' as shown in the diagram above. At each crossover point there may be a misclosure, or difference between the Signal values on the acquisition and tie lines.

INTREPID examines the misclosure of a target crossover and that of its four neighbours along the lines. (For example, in the above diagram crossover A has neighbouring crossovers with misclosures, M_1–M_4.

INTREPID makes a first estimate of the correct value for each crossover as the mean of its two Signal values.

It then adjusts the proposed correction of the target crossover using the current estimates for the neighbouring crossovers and their average original misclosure.

After calculating a new current estimate for the target crossover, INTREPID then makes the next crossover the target crossover (This would be crossover B in the diagram above, and crossover A becomes one of its neighbouring crossovers), and performs the same adjustment for it. INTREPID continues until all it has adjusted all crossovers.

INTREPID then repeats the process on all crossovers in reverse order. This two way pass makes up one loop closure iteration.

INTREPID performs a number of iterations and notes the changes to the crossover estimates. Repeated iterations will reduce and distribute the overall misclosure for the dataset.

INTREPID terminates the iterations after it has performed a specified number or when the average change for crossovers falls below a specified level.

This algorithm can be simply improved to also follow the same steps, but genralised to vectors and tensors, provided the appropriate swums, divisions, and rotational algebra, are carefully created and tested. This is what INTREPID have implimented.

1.[3] Green, A. A., A comparison of adjustment procedures for leveling aeromagnetic survey data, *Geophysics*, 48 (6) (June 1983), 745–753

© 2012 Intrepid Geophysics

Loop closure parameters

The loop closure process uses two parameters. If you wish to change them you must use a task specification (**`.job, or .task`**) file for the Levelling process and edit the file according to your requirements. You can use the file in interactive or batch mode.

Max_Iterations controls the maximum number of loop closure iterations performed. The default value is 500.

Max_Change When the average change to the crossovers in an iteration falls below the value of this parameter, the process will stop. The default value is 0.01.

See Displaying options and using task specification files for more information.

Process reports for the loop closure method

You can inspect a report of the progress of the loop closure process and the original and final average misclosure. *Under Unix* this appears in the background window. *Under Windows* it can be written to an **`WINXX.username.log`** report file. See "Diagnostic reporting options" in Configuring and using INTREPID (R04) for more information about background window or **`ntout`** file reports.

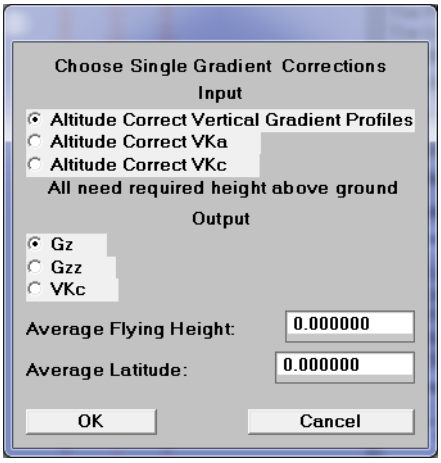
Single Gradient Corrections

Gedex and Rio have invested significantly in single gravity gradient measuring systems in the hope that this strategy will deliver a superior signal for detecting ore-bodies, compared to a full tensor gradient system. One channel measured with a 1 Eotvos noise envelope maybe more easily achieved than 6 channels with 2E. The hope has also been that Fourier theory can be used to recover what has not been measured, in terms of the other tensor gradient components. This is easy enough to propose, but of course, *Mother Nature* has her own ways, and you tend to get nothing for nothing in this type of context. The spatial indexing technique described in the next section probably gives you the best chance at something which yields stabilised estimates of non-measured components, while still residing in the profile world. Otherwise, you have to level and grid your signal before you have any chance, and with those steps, you immediately lose 80% of the signal content along the profiles, and so the high frequency resolving power you have hoped for is immediately compromised. Transverse gradients are very important when defining sources off line. Any anomaly bull's eyes will also remain under the profile and not off-line. This is not an issue with FTG data. All teachers of geophysics and would be inverstors in geophysical survey instruments take note.

Not withstanding this dilemma, there are simple trasnform that can successfully be undertaken using gravity gradient component measures that are non-conventional. this part of the tool is strictly alpha only, as there are still no fiully operational

© 2012 Intrepid Geophysics

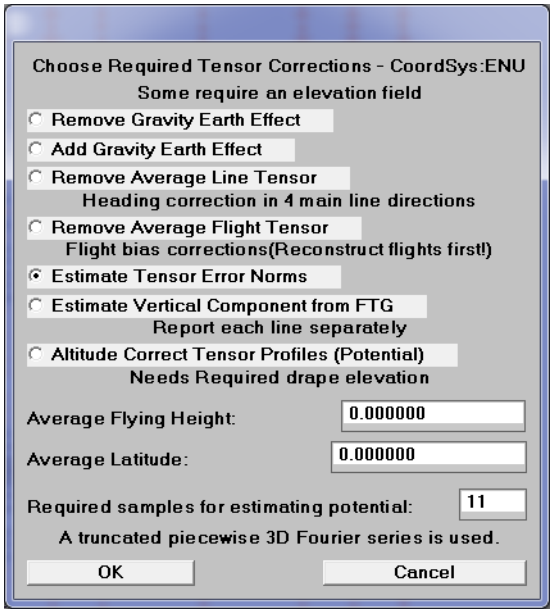
examples of commercial grade systems in operation as yet.



The options deal with converting a Rio style instruments signal to other more conventional signal types.

Tensor Corrections

New to V4.5 is the tensor corrections selections. While many of the previous algorithms already work on the generalised notion of a geophysical signal, some tensor specific algorithms are also required that do not work on scalar signals. Some of these are light weight, as in the Earth effect for the Full tensor Gravity Gradiometry signal, and some make heavy use of local approximation theory based upon 3rd order truncated Fourier series equation fitting.



All the methods in this section are profile based.

The first two options are FTG specific, with a simple model for the Earth gravity tensor effect at the surface, based around the Free Air correction gradient of 3048 Eotvos. As most survey data does not have this portion of the signal present, as it is not really being measured, this is academic.

The option to remove a calculated Heading tensor error in each of the 4 cardinal flying directions for a standard survey is given next. If you try this, examine the

© 2012 Intrepid Geophysics

levelling report to make sense of the statictical reporting, followed by application of average difference tensors.

The next option is similar, but is flight based statistically.

Estimating the Frobinus error Norm is a QC option. An 11 point window is passed down each profile, with the signal at the middle point in the filter subtracted from the estimated signal, using 5 points either side. The Norm of the difference tensor is then saved to the output channel, as a primary indicator of the background noise in the measured signal.

Using somewhat similar techniques, instead of estimating the middle point's tensor signal, it is equally easy to integrate the tensor and estimate the vertical component, which for gravity, is quite interesting. Remember this is high passed, and cannot have much longer wavelength present.

Perhaps the most challenging levelling method is to drape continue the measured tensors from an observed flying height, to another surface height. This is required for joining surveys together and various other purposes. The algorithmic challenge here is to constrain the cross-gradient terms locally, as data on adjoining lines must be referneced to accomplish this feat. With V5.0, we now use a spatial indexing technique to sort all the observed data for a survey into a local neighbourhood context. this then makes it easy to find observed tensors values locally in all directions, not just along profiles, os we then can successfully do the required continuations without having numeric instabilities. Use more samples, and you will get a smoother result, that is less "high-passed"

Creating and Using Crossovers Datasets

INTREPID can create a crossovers dataset which consists of all the crossover points in the original line dataset, including the unadjusted and adjusted values for a specified data field.

The crossovers dataset mimics the original dataset in that it is a line dataset covering the same region with the same number and location of lines. It differs in that it contains only data points which occur at the crossover points.

Crossover datasets act as a check point, allowing you to investigate and reflect on your current task using them instead of always having to re-establish them from the original data.

INTREPID does not save any Levelling parameters you have specified. When you load a crossover dataset to continue working with it you need to respecify the corrections.

You can perform trial gridding[1] on crossovers datasets and examine them using INTREPID tools such as the Spreadsheet Editor, Profile Editor and visualisation tools.

1.[4] The grid may provide an aid to interpreting the crossovers dataset even though it may not resemble a conventional grid.

© 2012 Intrepid Geophysics

Saving and loading crossovers datasets

>> To save the crossovers

Calculate the crossovers then choose Save Crossovers from the File menu. INTREPID displays the Save Crossovers dialog box. Specify the name of the crossover dataset and choose Save. (See Specifying input and output files for general information about loading and saving data.)

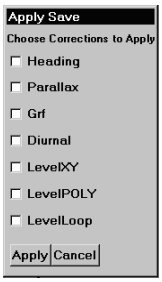
© 2012 Intrepid Geophysics

>> To open a crossovers dataset

1 Choose Open Crossovers from the File menu. INTREPID displays the Open Crossovers dialog box.

2 Specify the dataset. (See Specifying input and output files for general information about loading and saving data.)

INTREPID will prompt you to specify which sets of proposed corrections from the crossovers dataset to retrieve and treat as current proposed corrections.



This dialog box contains a check box for each set of proposed corrections contained in the crossovers dataset.

3 Turn on the check boxes for the corrections you wish to load as the current proposed corrections, then choose Apply / OK.

- INTREPID will load the crossovers dataset.
- INTREPID will adopt the selected crossover-based proposed corrections.
- Immediate proposed corrections are for information only in the crossovers dataset and have no effect on any immediate correction operation in this tool.

Crossovers dataset description

The crossovers dataset is a line dataset containing crossover information along each line of the dataset containing the crossovers.

Since each crossover point occurs at the intersection of two lines, there are two records of each crossover, one from the acquisition line and one from the tie line. In each record there is information about both lines. Each group in the crossovers dataset contains a line labelled **LNUM** which intersects with one or more other lines labelled **TNUM**. Therefore a histogram of the misclosures in the crossovers dataset will appear symmetrical around zero, since each misclosure occurs twice in the dataset, one having a positive value, the other having a negative value.

The **BETA** misclosure is the proposed new misclosure after levelling corrections have been applied. The initial value for **BETA** is the same as the misclosure value. It gets progressively altered as each levelling attempt is applied. Normally a single levelling pass is done, but it is possible to do repeated levelling. In this case INTREPID stores all Signal value corrections as changes to the misclosure, and **BETA** represents the final misclosure value after all levelling attempts have been applied.

© 2012 Intrepid Geophysics

For each crossover point the dataset has the following fields:

Field	Description
FLIGHT	Flight number of the line ('group by' field)
LNUM	Line number ('group by' field)
TYPE	Line type ('group by' field)
TIEFLIGHT	Flight number of other line at the crossover point
TNUM	Other line number at the crossover point
LFID	Fiducial value on the line at the crossover point. It will usually be fractional because crossover point will most likely be between two original data points.
TFID	Fiducial value on the other line at the crossover point. It will usually be fractional because the crossover point will most likely be between two original data points.
X	X location of crossover point
Y	Y location of crossover point
Signal	Original Signal value on the line at the crossover point
LGRAD	Gradient of the Signal profile on the line at the crossover point (or near it if you used the search radius). See Crossover gradients for further details about crossover gradients.
FLAG	Flag indicating whether the crossover is enabled
MISCLOSURE	Original misclosure
BETA	Sum of all proposed corrections expressed as a revised misclosure. INTREPID only calculates this if you specify XY, polynomial or loop closure correction.
DIURNAL	Proposed Diurnal correction
HEADING	Proposed Heading correction
IORAGRF	Proposed Earth's core magnetic field correction
LOOPDELTA	Proposed Loop Closure correction
POLYDELTA	Proposed Polynomial correction
XYDELTA	Proposed XY correction to Signal field of the line
XDELTA	Proposed XY correction to X field of the line
YDELTA	Proposed XY correction to Y field of the line
Signal	The interpolated signal at the cross-over position

Possible operations with reloaded crossovers datasets

You can use reloaded crossovers datasets for enabling and disabling crossovers and for viewing crossovers data and as a source of crossover-based corrections to apply to the dataset to be levelled.

© 2012 Intrepid Geophysics

If you load an existing crossovers dataset during a Levelling session, you can

- Specify which sets of crossover-based proposed corrections from the crossovers dataset INTREPID should retrieve and treat as current proposed corrections. (See Proposed corrections and crossovers datasets for details.)
- Examine crossover data in the Individual Crossover Display Area. (See Examining individual crossovers for details.)
- Enable and disable crossovers. (See Excluding crossovers from the levelling calculation for instructions.)
- Examine the crossover data using options from the Display menu. (See Display style—markers vs colours and Crossover and line display options for instructions.)
- Respecify corrections as required. (See INTREPID Levelling corrections.)
- Save a new copy of the crossovers dataset if required. (See Saving and loading crossovers datasets for instructions.)

Viewing the crossovers dataset as a point dataset

You can view the crossovers as either a line or point dataset in INTREPID tools if desired. If you wish to view crossovers as a point dataset you must first prepare it.

>> To prepare and view a crossovers dataset as a point dataset

1 Create a file with the extension **`..PNT`** in the crossovers dataset directory. INTREPID will not look inside this file, so it may have any content.

2 Open the crossovers dataset as a point dataset in the tool you wish to use.

If you are using the Flight Path Editor, choose Cancel when INTREPID prompts you for the Signal fields for point colour and size.

INTREPID displays the dataset as a point dataset.

Display style—markers vs colours

You can display data for crossover points using crossover markers or crossover colours.

Crossover markers are cross '+' symbols. They are black if they represent a negative quantity and red if they represent a positive quantity. Their size directly corresponds to the magnitude of the quantity they represent.

Crossover colours are coloured dots. Their colour corresponds to a value according to a table of value ranges and colours within the Levelling program.

>> To select crossover markers or colours:

Choose Markers or Colours from the options in the Style menu.

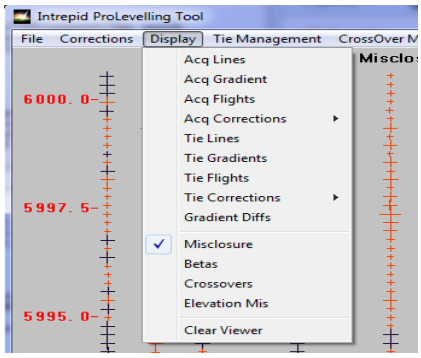
© 2012 Intrepid Geophysics

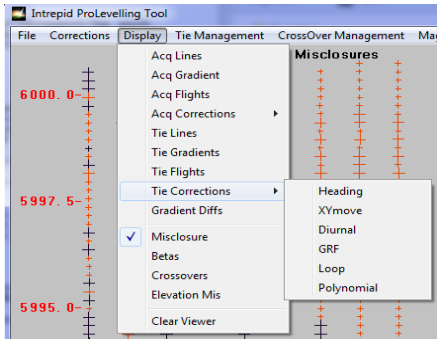
Crossover and line display options

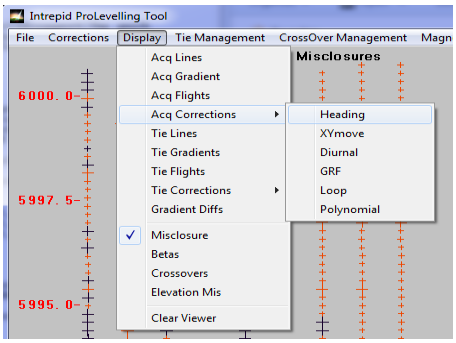
You can view a wide variety of crossover data graphically in the dataset display area. INTREPID represents the values as markers or using colours for different ranges. See Display style—markers vs colours for details.

>> To choose a display option:

Choose the data for display using the Display menu or its cascades.





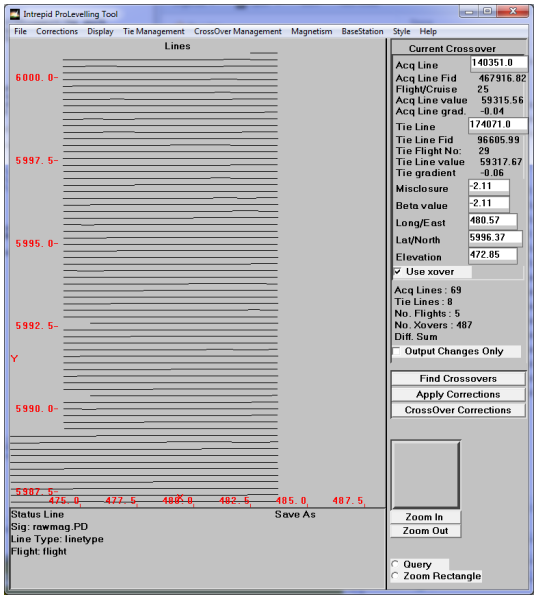


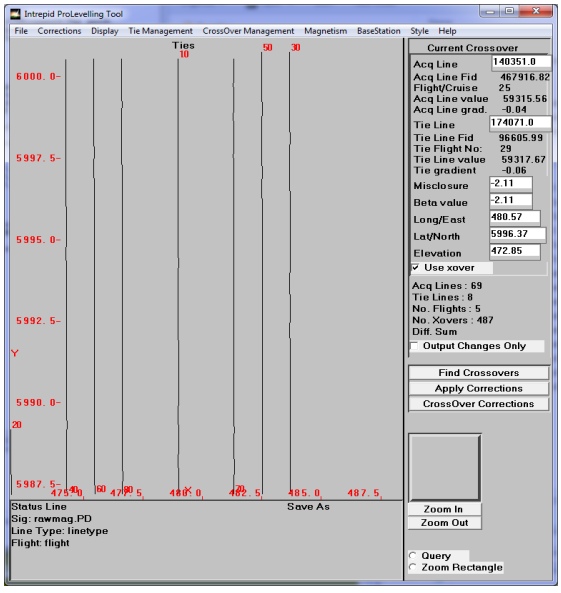
© 2012 Intrepid Geophysics

The following table lists the available display options

Data displayed	Representation	Menu option
Crossover points	black points	Crossovers
Misclosures	colours or red and black '+' symbols	Misclosure
Beta misclosures		Betas
Acquisition line or tie line paths	lines	Acq Lines, Tie Lines
Acquisition line or tie line crossover gradients	colours or red and black '+' symbols	Acq Gradients, Tie Gradients
Acquisition line or tie line flight paths	coloured lines—one colour for each flight	Acq Flights, Tie Flights
Difference between acquisition and tie line gradients	colours or red and black '+' symbols	Gradient Diffs
Size of Signal value corrections to acquisition line and tie line data		Acq Corrections **–>** Tie Corrections **–>**
Heading corrections	colours or red and black '+' symbols	Heading
Level XY corrections	squares with line vectors	XYmove
Diurnal corrections	colours or red and black '+' symbols	Diurnal
GRF corrections		GRF
Loop closure levelling corrections		Loop
Polynomial levelling corrections		Polynomial

The following illustrations show displays from the Display menu options.





© 2012 Intrepid Geophysics

Displaying profiles along individual tie lines

You can display crossover data using profile graphs along individual tie lines. INTREPID uses a separate window to display the values as a profile graph (with fiducials on the horizontal axis).

You can display data from the crossover points of a single flight or all flights.

>> To display data as a profile graph along a tie line:

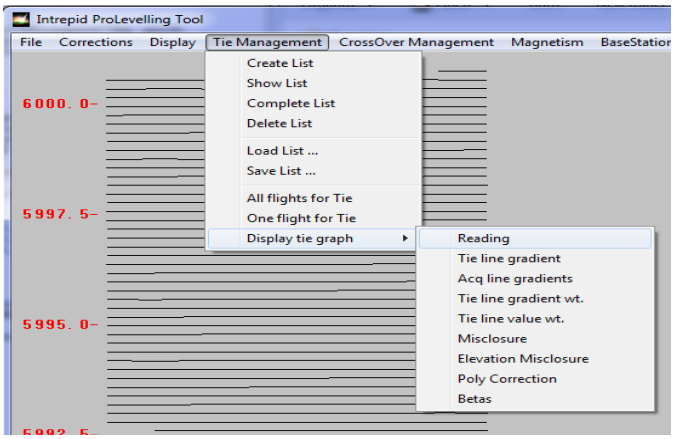
1 Ensure that the flights are reconstructed (See Chronological order—reconstructing the flights for full instructions).

2 Choose the All Flights for Tie or One Flight for Tie option from the Tie Line menu.

All Flights for Tie If you choose this, INTREPID displays the profile for the whole tie line.

One Flight for Tie If you choose this, INTREPID displays the profile for crossovers whose acquisition line belongs to one selected flight.

3 Choose the display option you require from the Display Tie Graph cascade in the Tie Line menu.



The profiles will show the values specified for each crossover:

Readings The original Signal value of the tie line.

Acquisition line gradients The gradient of the acquisition line Signal values.

Tie line gradients The gradient of the tie line Signal values.

Tie line gradient weights The Polynomial levelling weights for the tie line gradients. (See Crossover weighting methods).

Tie line value weights The Polynomial levelling weights calculated as √Signal values. (See Crossover weighting methods).

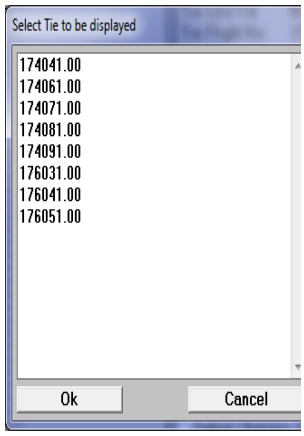
Misclosures the difference between acquisition and tie line Signal values.

Polynomial Corrections The current Polynomial proposed correction.

Betas (Beta Misclosures) The current running total of proposed corrections expressed as a modified misclosure. (See Proposed corrections and the beta misclosure for a definition).

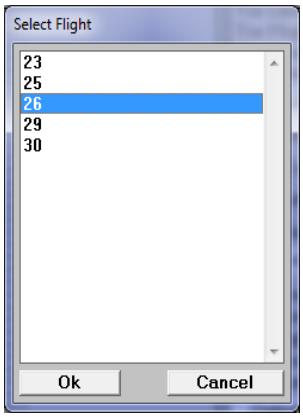
© 2012 Intrepid Geophysics

4 INTREPID displays the Select Tie to be Displayed dialog box.



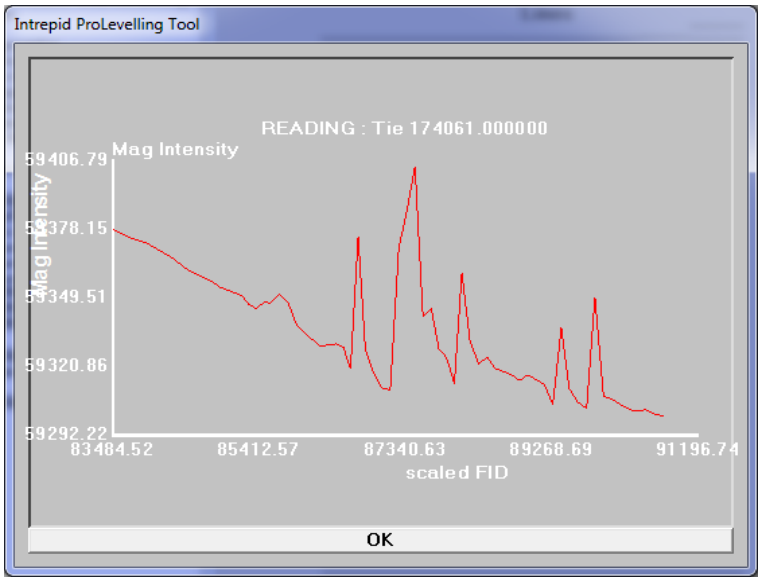
Select (click) the number of the tie line you wish to examine, then choose OK.

5 If you selected the One Flight for Tie option in step 2 above, INTREPID displays the Select Flight dialog box.



Select (click) the number of the flight you wish to examine, then choose OK.

INTREPID displays the tie line profile in a separate window.



6 When you have finished viewing the display, choose OK. INTREPID will close the Display Along Individual Tie Lines window.

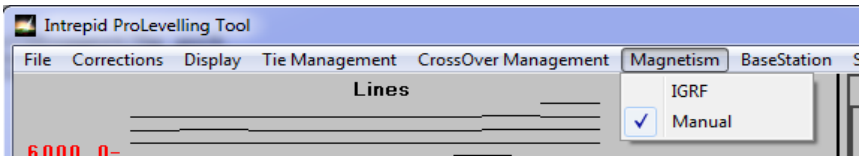
© 2012 Intrepid Geophysics

The Geomagnetic Reference Field calculator

You can use this calculator to obtain a Geomagnetic Reference Field (GRF) value for any location expressed in latitude and longitude.

>> *To use the GRF calculator*

1 Choose AGRF or IGRF from the Mag Field menu.



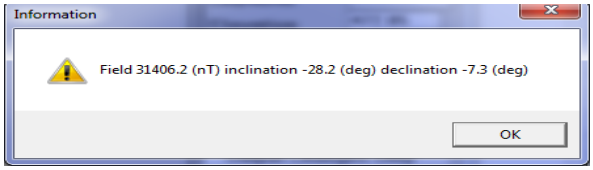
INTREPID displays the GRF calculator dialog box.

Enter 6 fields blank seperated height (m) lat (deg) lon(deg) date (dd mm yyyy)
Enter 6 fields blank seperated height (m) lat (deg) lon(deg) date (dd mm yyyy)
100.0 0.000 0.000 01 1 2000
Ok
Cancel

2 Enter in the parameters text box, separated by spaces:

- Height of location (in metres)
- Latitude of location (in degrees)
- Longitude of location (in degrees)
- Date for the calculation (in the format *dd mm yy*).

3 Choose OK. INTREPID displays the value in the GRF value dialog box.



Intl. GeoMagnetic Reference Field magnitude, inclination and declination
See The geomagnetic reference field in INTREPID (R15) for an explanation of these parameters.

© 2012 Intrepid Geophysics

Suggested levelling procedures for different cases

Levelling suggestions—case 1

An old survey, badly levelled, without any time based information such as Flight Date/Time or Fiducial record.

Suggested corrections:

Parallax, GRF, Heading, LevelXY, Loop

Suggested procedure:

If you grid the data you may be able to see levelling **busts**[15] in the grid.

If these are alternate highs and lows corresponding to traverse lines, try the Heading correction.

You can estimate the corrections required by examining Signal values at different places in the grid using the Visualisation tool (see "Querying points" in Visualisation (T26)).

Alternatively you can calculate mean Signal values for each group (traverse line) using the Spreadsheet. If these means are alternately high and low, you can calculate the value for the Heading correction from their difference.

Levelling suggestions—case 2

A full original located data set is available including all time variables.

Suggested corrections:

All Levelling options are available.

Suggested procedure:

1. If base station data is available, perform the Diurnal correction.
2. Make the GRF correction.
3. Apply the corrections and save the new Signal values.
4. Try to improve the coherency of the features in the data by experimenting with parallax corrections. Use positive and negative corrections.
5. Starting with the Diurnal and GRF corrected data, calculate crossovers again and look at the misclosures. You can obtain more information about its current state by creating a trial grid based on either the full dataset or the reduced crossover dataset.
6. Perform a Polynomial correction.

Levelling suggestions—case 3

A full tensor gravity gradient survey is newly acquired, and you wish to get a sense of the turbulence encounted, as the survey was flown.

Suggested query:

1. Use the tensor correction, calculate the Frobinius Norm field
2. Apply the correction and save the new QC signal field.
3. Examine this field in the flight path plot tool

1.[5] Levelling **busts** - patterns in the grid that look as if they are associated with discrepancies in flight data.

© 2012 Intrepid Geophysics

4 Alternatively, grid the new field and examine the flight lines for noise levels.

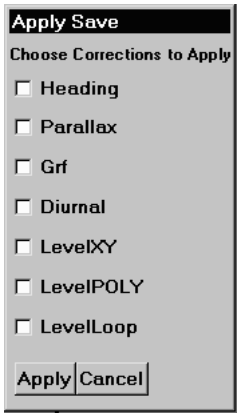
© 2012 Intrepid Geophysics

Applying the corrections to the whole dataset

After you have specified your corrections for the dataset to be levelled you can apply the corrections to all data points.

>> To apply the corrections to all data points:

1 Specify whether to save new corrected X, Y and Signal values or values of corrections in the output field using the Output Changes Only check box below the individual crossover display area (turn off for corrected values). You are most unlikely to see the following pop-up, as you would need to be simultaneously having BETA change sets for each of the listed correction types. The usual situation is to ask you to confirm you want to commit to the change set from the single levelling method you have been using.



2 Choose Apply Corrections near the bottom right corner of the Levelling window. INTREPID displays the Choose Corrections to Apply dialog box.

This dialog box contains a check box for each correction that you have specified in this session or that was present in the last crossovers dataset that you loaded.

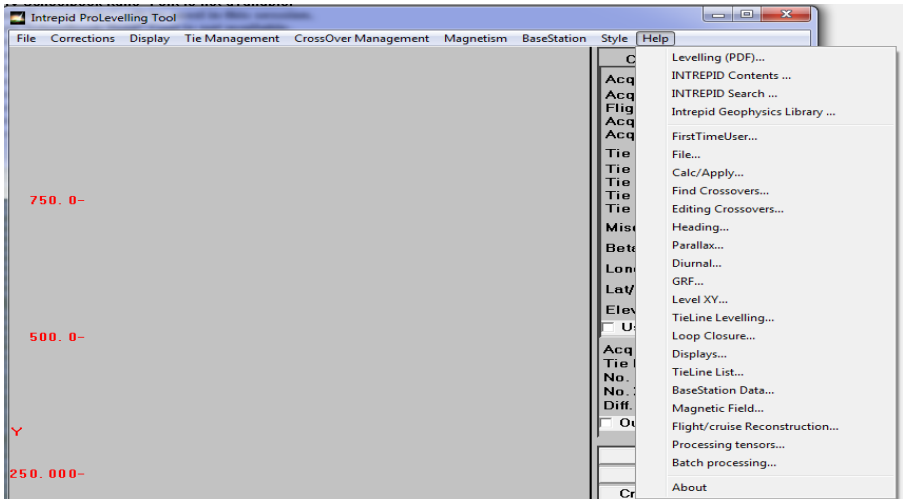
3 Turn on the check boxes for the corrections you wish to apply, then choose Apply. INTREPID will apply the corrections to the whole dataset.

4 If you wish to apply other already specified corrections, go to step 1.

Help

You can use the Help menu to display help text on the topics shown in the menu illustration below.

© 2012 Intrepid Geophysics



© 2012 Intrepid Geophysics

Exit from the Levelling tool

>> To exit from the Levelling tool

1. Check that you have saved any crossover or corrected data files that you wish to keep.
2. Choose Quit from the File menu. INTREPID will close the Levelling window.

Displaying options and using task specification files

Displaying options

You can view a list of the files and parameters options you have set for the current Levelling session by saving a task specification file (see next section) then viewing it in a text editor.

You can view graphically the effects of options that you have set in the Levelling window. See Display style—markers vs colours and Crossover and line display options for instructions.

Examining the crossovers dataset is another way of obtaining information about your specifications in a Levelling session (See Creating and Using Crossovers Datasets for details).

Using task specification files

>> To create a task specification file with the Levelling tool

1. Specify all files and parameters.
2. If possible, execute the task (choose Apply) to ensure that it will work.
3. Choose Save Options from the File menu. Specify a task specification file (INTREPID will add the extension **`.job`**) INTREPID will create the file with the settings current at the time of the Save Options operation.

For full instructions on creating and editing task specification files see INTREPID task specification (`.job`) files (R06). V5.0 Intrepid also re;leases GOOGLE protobuf syntax for this tool, thereby deprecating this older *PARMS* syntax. In the examples directory distributed with the software, are directories *jobs/levelling* and *tasks/levelling*. Identical processes are given there with both syntaxes, so you can compare and contrast the changes forced by the adoption of the GOOGLE parser/messaging technology. it is very close fit, and the benefits far outweigh the downside of making this change.

4. you get access to the full data/processing model for all of Intrepid and Geomodeller via the ***.proto** files we now distribute at V5.0.
5. The GOOGLE parsers are very good at reporting syntax errors in the language down to line and column.
6. INTREPID can move to a client/server, super computer/cloud computing architecture, with a completely independently designed and supported messaging language as the glue. This is after all one of the technologies upon which GOOGLE runs its business.

>> To use a task specification file for a batch mode Levelling task

Type the command **`newlevel.exe`** with the switch **`-batch`** followed by the name (and path if necessary) of the task specification file.

© 2012 Intrepid Geophysics

For example, if you had a task specification file called **surv329.job** in the current directory you would use the command

```
newlevel.exe –batch surv329.job
```

Note: The current version of INTREPID cannot load task specification files for interactive use. You can load previously specified operations to some extent using crossovers datasets, but these operate differently from task specification files. See Creating and Using Crossovers Datasets for information about crossovers datasets.

Task specification file examples

Examples of Levelling task specification files appear below.

Example 1—All corrections except polynomial levelling - *PARMS* syntax

```
Process Begin
   Name = newlevel
   InputZ = /disk1/surveys/ebagoola_S/raw_mag
   InputX = /disk1/surveys/ebagoola_S/x
   InputY = /disk1/surveys/ebagoola_S/y
   inputFid = /disk1/surveys/ebagoola_S/fid
   TYPEName = /disk1/surveys/ebagoola_S/linetype
   inputLine = /disk1/surveys/ebagoola_S/line
   inputFlights = /disk1/surveys/ebagoola_S/Flight
   DiurnalFlight = /disk1/surveys/base1/Flight
   DiurnalFid = /disk1/surveys/base1/fid
   DiurnalReading = /disk1/surveys/base1/diur_mag
   OutputZ = /disk1/surveys/ebagoola_S/z_lev
   OutputX = /disk1/surveys/ebagoola_S/x_lev
   OutputY = /disk1/surveys/ebagoola_S/y_lev
   OutputXover = /disk1/surveys/eba_xover
   Parameters Begin
      Save_Changes_Only = No
      Gradient_Radius = 10.0
      SurveyStyle Begin
         FID_Factor = 0.1
         Use_XY_Accuracy = No
#if not reconstructing flights use the following line
#        Reconstruct_Flights_by_Date = No
         Reconstruct_Flight_Method = Date_Fid
         Date_Style = YYMMDD
         Diurnal_Style = FLIGHT_DATE_TIME
      SurveyStyle End
      Zfilter = None
      HeadingCorrection Begin
         Bearing_Corrections = {"0.0/0.10
                                90.0/0.10
                                180.0/0.02
                                270.0/0.05"
                               }
         Headings =            {"0.0/0.10
                                90.0/0.10
                                180.0/0.02
                                270.0/0.05"
                               }
```


© 2012 Intrepid Geophysics

```
      HeadingCorrection End
      ParallaxCorrection Begin
         Cable_Length = 100.0
      ParallaxCorrection End
      DiurnalCorrection Begin
         Time_Lag = 0.1
      DiurnalCorrection End
      GrfCorrection Begin
         Sensor_Elevation = 50.0
         UseClearance = No
         Year = 96
         Month = 08
         Day = 25
         GrfType = Igrf
         Recalculation_Interval = 60.0
      GrfCorrection End
      LevelXYCorrection Begin
         Radius = "5.0"
      LevelXYCorrection End
      LoopCorrection Begin
         Max_Change = 0.01
         Max_Iterations = 500
      LoopCorrection End
   Parameters EndProcess End
```

Notes

In loop closure levelling you can modify the **Max_Change** and **Max_Iterations** parameters by changing the value in the corresponding line. See Loop closure parameters for details.

Example 2 Polynomial levelling, Julian flight date and time - *PARMS* syntax

```
Process Begin
   Name = newlevel
   outputXover = /disk1/survey/eba/eba_xo1_btch
   InputZ = /disk1/survey/eba/eba_mag/dtm
   InputX = /disk1/survey/eba/eba_mag/X3
   InputY = /disk1/survey/eba/eba_mag/Y3
   inputFid = /disk1/survey/eba/eba_mag/fid
   TYPEName = /disk1/survey/eba/eba_mag/linetype
   inputLine = /disk1/survey/eba/eba_mag/line
   inputFlights = /disk1/survey/eba/eba_mag/flight
   OutputZ = /disk1/survey/eba/eba_mag/poly_dtm2
   Parameters Begin
      Save_Changes_Only = No
      Gradient_Radius = 10.0
      SurveyStyle Begin
         FID_Factor = 0.8
         Use_XY_Accuracy = No
         Reconstruct_Flight_Method = Julian_Fid
         Date_Style =YYMMDD
         Diurnal_Style = JULIAN_TIME
      SurveyStyle End
      PolynominalCorrection Begin
```


© 2012 Intrepid Geophysics

```
                        Level_to_Principal_Tie = Yes
                        Tie_line Begin
                           Poly_Order = 3
                           Piecewise_Window = 80
                           Smoothing_Length = 15
                        Tie_line End
                        Drift_Flights_onto_Ties = Yes
                        Flight Begin
                           Poly_Order = 2
                           Piecewise_Window = 80
                           Smoothing_Length = 5
                        Flight End
                        Drift_Traverses_onto_Ties = Yes
                        Traverse Begin
                           Poly_Order = 0
                           Piecewise_Window = 50
                           Smoothing_Length = 5
                        Traverse End
                        Drift_Ties_onto_Traverses = No
                        Tie_Traverse Begin
                           Poly_Order = 3
                           Piecewise_Window = 50
                           Smoothing_Length = 5
                        Tie_Traverse End
                        Poly_Iterations = 1
                        PolyTieListFile=/disk1/survey/eba/tie1.parm
                     PolynominalCorrection End
                  Parameters End
               Process End
```

Tensor Altitude drape correction Example - *Protobuf* syntax

```
# Example task file V5.0 protbuf syntax - levelling
# Usage: fmanager -batch tensor_drape_correction.task
#
# Show an altitude correction for the FTG processing

IntrepidTask {
       Levelling {
                InputZ: “D:/test_data/FullTests/tensor/drape_corrections/mauritania_ftg_subset_Intrepid..DIR/
Tensor_FAlev”;
                InputX: “D:/test_data/FullTests/tensor/drape_corrections/mauritania_ftg_subset_Intrepid..DIR/
X”;
                InputY: “D:/test_data/FullTests/tensor/drape_corrections/mauritania_ftg_subset_Intrepid..DIR/
Y”;
                inputFid: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/GS_Fiducial”;
                TYPEName: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/GS_LType”;
                inputLine: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/GS_Line”;
                inputFlights: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/GS_Flight”;
                InputHeightAboveSpheroid: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/Altitude”;
                InputRequiredHeightAboveSpheroid: “D:/test_data/FullTests/tensor/drape_corrections/
mauritania_ftg_subset_Intrepid..DIR/Drape”;
                OutputZ: “D:/test_data/FullTests/tensor/drape_corrections/mauritania_ftg_subset_Intrepid..DIR/
Zout”;
                ReportFile: “prolevelling.rpt”;
                runType: Tensor_Level;  # select the main run type
                Save_Changes_Only: false;
                Gradient_Radius: 10.0;  # not needed
                FID_Factor: 0.1;
                Use_XY_Accuracy: false;  # not needed
                Date_Style: DECIMAL_YEAR;  # not needed
                Diurnal_Style: FLIGHT_DATE_TIME; # not needed
```


© 2012 Intrepid Geophysics

```
                # TensorCorrection parameters
                FlightBiases: false;  # used for a tensor heading correction
                Tensor_Adjustment: Profile_Adjust_Altitude;
                Tensor_Forcing: TENSORnote_Norm;  # used for loop levelling a tensor signal, how to measure
convergence?
                NumberSamples_EstimatePotential: 21; # the bigger the window, the smoother the result.
}}
```


© 2012 Intrepid Geophysics